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ART. I.—*Geological and Statistical Notice of the Coal Mines in the vicinity of Richmond, Va.;* by A. S. WOOLDRIDGE, President of the Mid Lothian Mining Company.

TO THE EDITORS.

Gentlemen—I have been delayed in replying to your letter of May last, hoping to receive from the respective owners of the coal mines, statistical statements of their mining operations, that I might transmit you more accurate and full information, than I can hope to furnish without such aid; but as I have failed in securing such assistance, I will submit such a statement, imperfect as it must be, as my knowledge and information enable me to furnish.

The coal-field of this vicinity lies about thirteen miles west of Richmond; is known to extend from about fifteen miles north of James river, south beyond the Appomatox river; is said to be some fifty miles in length, and in breadth about twelve miles—its bearing is some thirteen degrees west of south; it lies upon granite, and is supposed to be in the form of an ellipse; it outcrops to the east and west. The coal lies in six counties—Henrico, Hanover, Goochland, Chesterfield, Powhatan, and Amelia. The mines in Chesterfield county, near the Buckingham road leading from Richmond to Lynchburg, may be said, so far as the north and south points are regarded, to occupy the centre of the field on the eastern outcrop; and it is in this vicinity that the coal appears in its greatest thickness and purity; it varies from fifty

feet to some four or five feet in thickness.* A full and accurate account of the field and the quality of the coals is anticipated from the report of Professor Rogers, to be made to the next legislature of Virginia. It may be well perhaps to remark, that all the explorations and workings in this coal-field, have been confined chiefly to the outcrop or sides of the basin, and that there is nothing yet developed indicating with any degree of certainty how thick or deep the coal will be found imbedded in the centre of the field; but it is believed that enough has been ascertained, to show that so thick, varied, and valuable a deposit of bituminous coal, in the same space, is not to be found any where else.

The first mines discovered in this vicinity, were the old Black Heath pits, Buck & Cunliffe's, Ross & Curry's, Wooldridge's, Railey's, and the Green Hole, and on James river, in Chesterfield county, also, Trabue's and Sallee's pits. These have all been discontinued or worked out; they produced coal of excellent quality for smithing purposes, particularly the Old Black Heath mines.

The mines now in operation are the Maidenhead pits, known as the mines of the Black Heath Company of Colliers, discovered in 1821. There are at these mines several shafts, varying from one hundred and fifty to seven hundred feet deep; during the year before the last, Col. Heth, originally a large shareholder, purchased these mines of this incorporated company, with all their real estate and other property; he bought also Sallee's pits, with a large adjoining tract—intending to combine all these various tracts so as to form a new company, and with that object went out to England. While there, an explosion from inflammable gas occurred in his mines, and destroyed fifty three out of fifty six† persons who were in the pits. He brought out from England suitable men to reclaim his mines, which was done, and with him came agents sent out to examine and report as to the value of this property. He is now in England, closing a sale of the whole of this property, and the agents of the

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* It is probable that this coal-field extends through Virginia into North Carolina.

† One of the persons who survived, was one of three descending the shaft in a basket; they were thrown up in the basket to the full length of the rope running over pulleys at the pit-head frame, that was forty feet above the surface; they were thus thrown probably seventy feet high. The man saved, who remained in the basket, had both thighs fractured.

English company are expected out to put these mines under work—the water being kept out, so that they can be put in working operation at any time. On the Maidenhead tract, are two deep shafts, the one in which the explosion took place, about seven hundred feet in depth, and the other completed during the last year, about six hundred feet deep. The coal from these mines is of good quality, averaging thirty six feet in thickness, and the two shafts can produce two million bushels of coal per annum. On this estate are all the buildings, engines, and other machinery necessary for a large business, with a railroad, the property of the company, leading from the pits to James river, and passing through the tract of land owned by said company, called Sallee's, containing a valuable deposit of iron ore, which it is presumed will shortly be worked extensively and profitably, as the ore is in the midst of the coal mines, intersected by the company's railroad, within a mile of James river, and not more than about twelve miles from Richmond. Explosions occurred several times in the Maidenhead pits, prior to the great explosion. On these occasions several men were killed and burned. At that time the art of ventilating coal mines was imperfectly understood here. Since that period, much greater, if not entire security, exists under the ventilation by Newcastle gas-men.

On the north of these works lie the mines owned by Thompson Blunt, now under a lease to Col. Heth, and best known as the pits of Wills, Brown & Co., of whom Col. Heth purchased the lease; but one shaft and that about four hundred feet deep to the coal, is in operation at these mines; at the bottom of the shaft there are two inclined planes, one worked by mule power and the other by steam. These slopes increase the depth about three hundred feet more; a steam engine is in operation over the pit. A force of about ninety hands is employed, including those at top and bottom and the cartmen; these pits being about two miles from the coal railroad leading from Manchester, which is the shipping point on tide water to most of the mines in the vicinity. The coal, which is about thirty feet thick, is of superior quality for smitheries, and the product about four hundred thousand bushels per annum. Several accidents by explosive gas occurred in these mines during the last year and preceding years, by which some lives were lost, and several men severely burnt. They are now wrought safely, under the management of Newcastle ven-

tilators. These mines were opened about twenty five years ago; during the first year's operation, when the miners were out at their dinner, about one o'clock in the day, and within an hour from the time they ascended, the pit fired and the flames instantly rushed from the shaft to the height of two hundred feet above the surface; whether this was caused by an explosion of gas or otherwise, is uncertain.*

Immediately adjoining these mines on the north, are those called the Gowrie pits, owned by Murchie, Mosely & Brander, and now worked under a lease by George E. Swann. There are two shafts on this property, one about one hundred and sixty feet deep, the other about four hundred and sixty; about eighty thousand bushels of coal will be hoisted from these mines the present year. The coal is about six feet thick; it is suited for grates, and for steam engines. The present prospect is not promising; the shafts seemingly have been sunk on troubles, and a good body of coal is supposed to lie on the dip of the present works. There are employed at these mines forty men, including top and bottom hands and cartmen, and they are about the same distance from the railroad as the last named mines. It is probable that these mines will not be worked the ensuing year.

Next on the northeast, are the old pits of Buck & Cunliffe, mentioned before as having been worked out; and on the northeast of them are the old Black Heath mines in like condition. About two miles north are Sallee's pits, named before as being unwrought, and containing iron ore lying over the coal, and now owned by the English company; in which company Col. Heth retains a royalty upon one half of the minerals owned by it, as well as in the coal property; on the north lie Trabue's old pits, extending to James river, now owned by Thomas M. Burfoot, and under a lease to Stanford, Duval & Co. who have sunk some shallow shafts south of the former workings, from fifty to two hundred and fifty feet deep. There will be raised from these mines during the present year about one hundred and twenty five thousand bushels of coal; they give employment to about fifty men. This coal being raised from near the outcrop, is not very suitable for any thing but domestic fuel. A new shaft is now sinking on

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* What other cause can be assigned? It is hardly possible that any felonious attempt could have produced such an effect.—Eds.

this land, and from the great influx of water, a small steam engine has been put up to aid in sinking. On the southeast of these mines, on the lands of Maj. Clarke, some years ago, coal was mined to a small extent.

We return now to the Maidenhead pits, being the point in the working mines where we began, and which lie on both sides of the Buckingham road; Wooldridge's old pits and Railey's, the property of Nicholas Mills, and before mentioned as being unwrought and exhausted, are directly east and adjoining. These mines were not abandoned until the close of the last year, having been for the last half dozen years worked by Mills, Reid & Co. East of these mines are the old Union pits not before named, but worked out, not having been wrought more than some fifteen years after being discovered. South of these, are the exhausted mines owned by Nicholas Mills, and known as Mills Creek pits; which like the Union pits did not last working more than twelve or fifteen years after being discovered. South of these are the old Green Hole pits, before named as one of the oldest pits and exhausted by working. The coal raised from all these old mines was of very good quality. Next and immediately south, lie the Creek Company's mines, discovered about four years ago. They were valued and sold to an incorporated company at $96,000. They have but one shaft in operation, about three hundred and eighty feet deep, worked by a steam engine on the ground, and mule power operating below on an incline.

The present year's product will be, as it has been for the two preceding years, about two hundred and fifty to three hundred thousand bushels of coal, and there are employed here about seventy men at top and bottom. The coal is of good quality, but is difficult to mine in consequence of the field being somewhat troubled. This company own all the necessary machinery, mules, and about thirty men, with a sufficient outfit of houses, two coking ovens, and a branch railroad connecting their mines with the main coal railroad to Manchester. On the south of these works and immediately adjoining, are the Stonehenge pits, now unwrought, owned by the heirs of Martin Railey, deceased. The old shafts at these mines are numerous, and vary in depth from fifty to four hundred feet; it is supposed that the coal extends to the dip of the old works,—new shafts it is supposed will be sunk, and extensive operations may in future be carried on.

The coal from these pits ignites easily and burns freely, being very suitable for grates, locomotives, &c., but unsuitable for smiths' use. There are several seams of these coals; the first from twelve to sixteen feet in thickness, the next twenty eight inches, the third four and a half feet. Other seams are known to exist below these, but have not been worked. These coals were discovered about thirty years ago, by a craw-fish bringing up coals to the surface above his hole. Wooldridge's old pits were discovered by the wheels of the waggons running on the Buckingham road turning up coal in the ruts; and the coal at the old Green Hole pits was said to be discovered by a deer jumping across the creek and throwing up coal on the snow. The time of the discovery is not accurately known.

The Mid Lothian Coal Mining Company's pits lie immediately south of the Maidenhead mines, southwest of Railey's pits, west of the Creek Company's mines, west and south of Stonehenge, and adjoin all these mines. This company procured a charter in 1835, and was organized in 1836. The sinking for coal preceded the organization of the company, and was in anticipation of it. The tracts of land contain four hundred and four and a half acres; upon the northeast corner, being the rise, a shaft had been previously sunk and worked; it is five hundred feet deep. By improvident mining, it crushed the pillars of coal, settled down, and was abandoned in 1836; there not being more than five or six acres worked by the then lessees. These lands, being two tracts, were valued at $300,000, and owned by Wm. Wooldridge's heirs, to wit, Dr. A. L. Wooldridge, Jane A. Elam, Charlotte Wooldridge and myself. The capital was divided into three thousand shares of a hundred dollars each; and one third, being one thousand shares, was sold to some thirty shareholders, in and around Richmond—generally, of the most respectable and wealthy class. The $100,000 cash, the amount thus raised, was given to the company as a capital for sinking, purchasing machinery, for laborers, &c. Four shafts were commenced, nearly in a line on the run of the coal, extending a mile or more. In the autumn of 1839, coal was found in one shaft, at the depth of seven hundred and twenty two feet to the coal, at which time the other three were temporarily suspended, one being six hundred and twenty five feet deep, one three hundred, and the other eighty five feet. These shafts are eleven feet

square, divided into four chambers by timbers, and from the samples of metals sent, you will see that sandstone and slate, in alternate layers, form the covering over the coal. The last shaft was recommenced at the beginning of the present year, and is now down three hundred and fifty feet, and it is expected coal will be reached by the first of next June, at the depth of six hundred feet. The last year about three hundred thousand bushels of coal were hoisted; the present year about six hundred thousand bushels will be raised, and the quantity would have been enlarged had the demand justified the increase. Coal in the working shaft was found, as before stated, at the depth of seven hundred and twenty two and a half feet from the surface—the coal in the shaft was thirty six feet thick, and the sink below the coal is sixteen and a half feet deep, making the whole depth of the shaft seven hundred and seventy five feet. I write now from memory, and may not be critically correct as to a foot. In the journal sent you of the metals,* the specimens and list commence about two hundred and forty feet below the surface. The upper metals in the samples kept, got mixed or deranged, and were thrown away. Any discrepancy (if any) in the journal of metals as kept, with the depth of the shaft as here given, must have been produced by the difficulty of measuring the thickness of the metals on the side of the shaft in sinking. The coal lies at an angle of about thirty five degrees, dipping to the west. The thickness of the coal varies, which is, I presume, produced by the form of the rock upon which it is deposited being uneven; in some places the coal rises to fully fifty feet in thickness. The whole capital was expended in sinking as above described; in procuring a large steam-engine, buildings, mules and mule-power machines, railroads above and under ground, besides some eighteen laborers, and a coal-yard and fixtures. The whole of the lands are supposed to contain coal. The exploring drifts now in progress, extend north and south over a quarter of a mile; the coal on the west being the dip, and on the east being the rise, seems to indicate great regularity,—a drift now going on to the southwest on a slope, shows that the coal is flattening off, it not dipping now more than one in ten feet, and in quality is of the most promising character. It will be seen by

* The miners' name for the rocks and other matters raised with the coal.—Eds.

observing the location of these mines, as stated before, that the lands take in the coal from the eastern outcrop, on the south, so as to reach over on the dip fully a mile, far beyond any explorations westward. The present works and fixtures are capable of producing one million of bushels per annum, and by the aid of a second engine over the same shaft, another million might be produced. The next year, when the sinking shaft shall have reached coal, two millions per annum can be raised, and that quantity doubled by increasing the steam power. Two large steam-engines are now building, and intended to be erected before the close of the season; one over the sinking shaft, and the other in the mines to operate on the incline.

As to the quality of the Mid Lothian coal, I refer to the samples sent you, and the certificates contained in my circular, also forwarded to you; adding this fact, that this coal upon trial has been found to suit a greater variety of purposes than any coal hitherto discovered; and of this you will find ample proof by attentively examining the circular referred to.

The whole effective force at these mines, including the coal-yard hands, and top and bottom hands, is one hundred and fifty men and boys, with some twenty five mules. Most of these mules will be discontinued as soon as the steam-engines are erected. The ventilation of the mines is committed to the management of a Newcastle miner or gas-man of much experience and skill, trained by Mr. Buddle, the distinguished English mining engineer.

The ventilation is kept up by means of brattice work of boards, and aided by a furnace under ground. The atmospheric air is taken down on one side of the shaft, and courses the whole drift, passing out by the furnace in the opposite side of the shaft. On the upcast side the air is received some thirty feet from the bottom of the pit into the shaft, and at the top it is boxed up so as to throw it off fifty feet above the mouth of the shaft. Large quantities of inflammable gas are thrown out from the coal in the mines constantly, and any interruption in the air coursing the mines with regularity, might and would be attended with disastrous consequences from an explosion of the gas. Sir Humphry Davy's lamp is used at the mines, more as a pioneer than otherwise; no mines are considered safe that require to be worked by safety-lamps. They ought to be used only in going through

the mines to see that all is right, before the miners are put to work; or to be used to free the mines in case they are overcharged with gas.

The interior of the mines contains iron railroads of a very simple construction. Iron bars, two inches by half an inch, are inserted edge up into cross pieces of timber, four by two inches, laid at the bottom of the drifts. The iron is admitted into the timber about an inch deep; no wedging is necessary, and the road can be curved at pleasure. Mules are used on these roads below, and thrive and look better there than those above ground.

Impressions of fishes and vegetable remains, such as ferns, bark, and knobs of wood, are often found in the slate lying over coal in this neighborhood. They were particularly numerous at the Union pits, and mines of the Creek Company, which seem to be a distinct formation of coal from the main formation, and many suppose it a deposit at an after date. As no sinking is now going on at either of these mines, I am unable to procure and forward you any samples, as the old ones have been disposed of. I will be upon the watch, and secure for you hereafter any specimens that may be obtained, and worthy of your attention.

The coal basin extends across Chesterfield county to the south to the Appomattox, or perhaps a little beyond the river into Amelia county. No coal, however, has been found of sufficient thickness to justify working, nearer the river than Rowlett's old pits, distant one mile to the north. Between these pits and Hill's old pits, distant five miles still farther to the north, is supposed to be the only part of this section of the basin that will be found valuable from the abundance of its mineral treasure. The coal measures may be traced on the north from these limits to the James river pits, and south a little beyond the Appomattox, but no exploration has yet discovered coal beyond the limits mentioned, in sufficient quantities to be wrought to profit.

Rowlett's pits mentioned above, were some twenty years since leased by a company of gentlemen in Petersburg, wrought for a few years and abandoned; subsequently an incorporated company purchased them, but after a trial of two years gave up further search for coal, having been unsuccessful, though the land is still owned by them. About twenty years ago Hill's pits were first put in operation. These were worked for five or six years, and likewise abandoned. The coal at both of these workings

was of excellent quality, and particularly well adapted to the use of grates and other purposes requiring gas and flame. The exceedingly faulty character of the field at both of these points led no doubt to the abandonment of these workings.

These are the only workings that had been attempted on the south side of this great coal basin, until two years since, when coal was accidentally discovered upon the lands of James H. Cox, next south of Hill's old pits and three fourths of a mile distant. This coal was first discovered on the side of a hill, where it had been uncovered by the washings of heavy rains; for the coal here along the whole line of outcrop reaches within a few feet of the surface, being only covered by a coating of soil, sand, and gravel. Since its discovery, an average of about twenty hands have been engaged in exploring and mining it, and from the explorations already made, the belief is entertained that no part of the basin presents a more regular, uninterrupted, and undisturbed formation than this. The thickness of the seam varies from seven to fifteen feet. The coal is of superior quality, and peculiarly suited to grate purposes, steam engines, the blast furnace, gas works, &c. The accompanying certificate* from Dr. Andrews, shows its richness in volatile matter, and the small quantity of ashes it contains. At present, the operations at these mines cannot be increased to any extent, in consequence of their distance from market, and the want of proper facilities for transportation. The present mode of transportation is to carry it in carts to the river, and thence by boats to Petersburg, at the cost in all of

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* To Charles Berg, Esq.—*Sir:* The specimen of bituminous coal from the Clover Hill coal mine, which you left with me for analysis, belongs to the variety called slate coal. It has a specific gravity of 1.26; principal fracture slaty; cross fracture uneven, brittle, slightly soils the fingers, and is composed of two alternate varieties, one velvet black with a brilliant lustre on the foliated fracture, the other dark grayish black, lustre glimmering. It ignites very freely, and burns with a lively yellow flame; cakes, but swells very little in coking.

One hundred parts contain—

Carbon,		55.
Volatile matter,		38.5
Alumine, Silex, Oxide of iron,	from the ashes,	6.5

It contains also a small portion of sulphur combined with the iron as a sulphuret.

The caking quality which it has, will make it a useful fuel for the forge, or for those purposes which require a hollow fire. For the manufacture of gas, I consider it superior to the caking coal of Newcastle, England, or the splint coal of

eight and a half cents. This high cost of transportation forbids, for a time, successful competition with mines enjoying greater facilities. It is designed to remedy this inconvenience by constructing a railroad to the Appomattox, a distance of five miles, or one to intersect with the Richmond and Petersburg road and reach James river some where about Osborne's or Bermuda Hundred. The country through which both of these routes would pass, is admirably adapted to the purpose, being very level and abounding in timber and other railroad materials. Either of these contemplated improvements would place these mines in a state of fair competition with any other mines in Virginia, or perhaps in this country.

These mines have recently been sold by James H. Cox to the Clover Hill Company, who are now working them with a force of twenty laborers. Moody & Johnson have a lease of Anderson's land, next adjoining that of the Clover Hill Company, and employ a force of twelve operatives. These two workings together, last year, produced two hundred thousand bushels of coarse grate coal; the fine coal not being able to bear the cost of transportation, is still remaining at the pits. Whatever has been said about the quantity and quality of the Clover Hill coal, is applicable to Moody & Johnson's coal, as all is taken from the same seam.

The deepest shaft which has yet been sunk is two hundred and fifty feet deep. The measures passed through were principally sandstones and shales. Impressions were frequently met with of ferns and other aquatic vegetables, but no fish or other animal remains.

Scotland, and next best to the cherry coal of Staffordshire. It contains 6 per cent. more volatile matter than the Richmond coal, which is now used at the gas factory in this city. It will answer very well for the grate, and make a cheerful fire.

The following table will show the quantity of volatile matter in each kind of coal mentioned, and also the quantity of ashes.

Cherry coal,	44.75	volatile	matter,	10	per cent.	ashes.
Splint coal,	35.	"	"	9.5	"	"
Richmond coal,	32.	"	"	8 75	"	"
Clover Hill coal,	38.5	"	"	6 5	"	"
Newcastle coal,	22 6	"	"	1.5	"	"

I am, sir, your obedient servant,

GEORGE W. ANDREWS.

Baltimore, Dec. 15, 1840.

The bearing of this part of the field is fifteen degrees to the west of south, and inclines to the west as you proceed to the south, until near the river it is thirty degrees. The same is the case on the western outcrop. This induces the belief that the basin is here rounding off, and that at no great distance to the south of the river, the coal formation entirely disappears. This belief is confirmed by explorations made on that side of the river.

Several mines were worked formerly on James River, on the western outcrop of the coal-field, in Powhatan County, which are now unwrought, principally because the coal both in quality and quantity is not equal to the coal of Chesterfield, and will not bear working in a depressed state of the trade.*

In Goochland County, on the western outcrop, coal of good quality was formerly worked, and known as the Dover pits, owned by Anderson & Moody, and conveyed to the Dover Coal Mining Company. These mines are not now worked, the company having failed. Since the failure of the Dover Company, the mines have reverted to the former owners; and on the east side of the outcrop, on the Goochland and Henrico side of James River, are several mines, some of them now in operation, and some not. The largest operators in that neighborhood, are the Messrs. Crouches & Sneed, the owners of extensive mines in good working condition, employing about one hundred and fifty hands, and raising four hundred thousand bushels of coal the present year. Near these mines, on James river, are those of the Tuckahoe Coal Company. The old mines are out of work, but a shaft is sinking, employing from fifteen to twenty hands, &c.

Near these are Woodward's and Cottrel's Mines, both now unwrought. Northeast of Crouches & Sneed's mines, lie the Edge Hill pits, now worked but not extensively, by Richardson, probably employing some thirty hands, and producing about eighty thousand bushels. On the north part of Crouches & Sneed's property, Townes & Powell are engaged in hoisting coal, but not working more than some twenty hands, producing the present year about one hundred thousand bushels. There may be some other mines in this vicinity not remembered. There is a railroad connecting these mines with the James River canal, down which the coal passes to Richmond. The coal on the north side of

* These mines were worked by three incorporated companies, all having failed.

James River sells for a less price than that on the south side, being considered not as good.*

Some four or five miles north of these mines, lie those called the Deep Run pits, worked by John Barr, who at present employs some forty hands, and raises some two hundred and fifty thousand bushels of coal; he uses steam power. This coal is of fair quality, as is also that from Burton's pits, now mined by Grubs & Co., who will probably raise about the same quantity as Barr, and employ as many hands. The coal from these mines is transported to Richmond by the Fredericksburg and Richmond Railroad Company, a branch of their road having been extended to the pits. The charge for coal on this road is four cents per bushel from the mines to Richmond. The charge for boating coal down the James River canal, including tolls, is about three cents from the mines,—that on coal passing the coal railroad in Chesterfield from the mines, to tide water, is five and a half cents;—for taking it from this road, at its junction with the Petersburg and Richmond railroad, two cents per bushel to Richmond,—to Petersburg four cents, including yardage at either place; and coal going by this road, to either Petersburg or Richmond, is entitled to half a cent per bushel deduction from the main coal road charge. The charge for transporting from the mines on the south side of Chesterfield County to Petersburg, is about eleven cents per bushel, by waggons. It is in contemplation to branch, at some future day, from the main coal road to Warwick, about five miles below the present shipping yards at Manchester, where vessels of large size can load with coal with great facility; a bar just above that place preventing large vessels from going up to Manchester or Richmond. The charge for transporting coal on the principal coal railroad is unusually high, but will soon be reduced. It being the first road of the kind in Virginia, it was deemed prudent to make the transportation high, a dividend of six per cent. per annum, payable semi-annually being authorized in the charter; the surplus raised from the five and a half cents per bushel, being pledged to the refunding of the capital subscribed; this application has been faithfully

* There is found in connection with the coal at Sallee's and Burfoot's pits in Chesterfield, and on the north side of James river at the mines generally, a substance formerly called dead coal, recently called natural coke, that has lately been used and very much approved as grate fuel.

made, until the whole of the capital, with the exception of some twelve per cent., has been repaid. When that is accomplished, the tolls are to be so reduced as to allow six per cent. upon the then nominal capital only, and to pay the expenses of transportation, at which time the charge for transportation ought to be reduced some two and a half cents per bushel; and if at that time the contemplated branching to Warwick shall take place, and locomotive power be substituted for the present expensive plan of using horse power, then the price of Virginia coal can be so lowered as to make it the interest of all consumers of bituminous coal on our Atlantic border to use it almost exclusively.

Richmond, Sept. 1, 1841.

*Remark by the senior editor.**—The coal of Virginia has been long known throughout the Atlantic states. From the Mid Lothian Coal Mines, we have recently received a series of specimens illustrative of the structure of this coal-field. It is based upon granite, and consists of the usual alternations of sandstones, shales, clays, and coal.

The coal is of an excellent quality; and it appears from printed certificates of many manufacturers, that it is used in very various operations requiring fire, especially in the different manufactures of iron both in light and heavy work, and it is said to have been recently introduced into the manufacture of copper.

Art. II.—*Regarding Human Foot-Prints in Solid Limestone;* by David Dale Owen, M. D., of Indiana, with a plate.

(Communicated for this Journal.)

The occurrence of representations of human feet in solid rock, has lately excited considerable attention, both in this country and in Europe. The intimate connexion of the subject with those great problems, the age of our race and the gradual peopling of our globe with animated beings, invests it with additional interest, in the eyes not only of the scientific explorer but of the general reader also.

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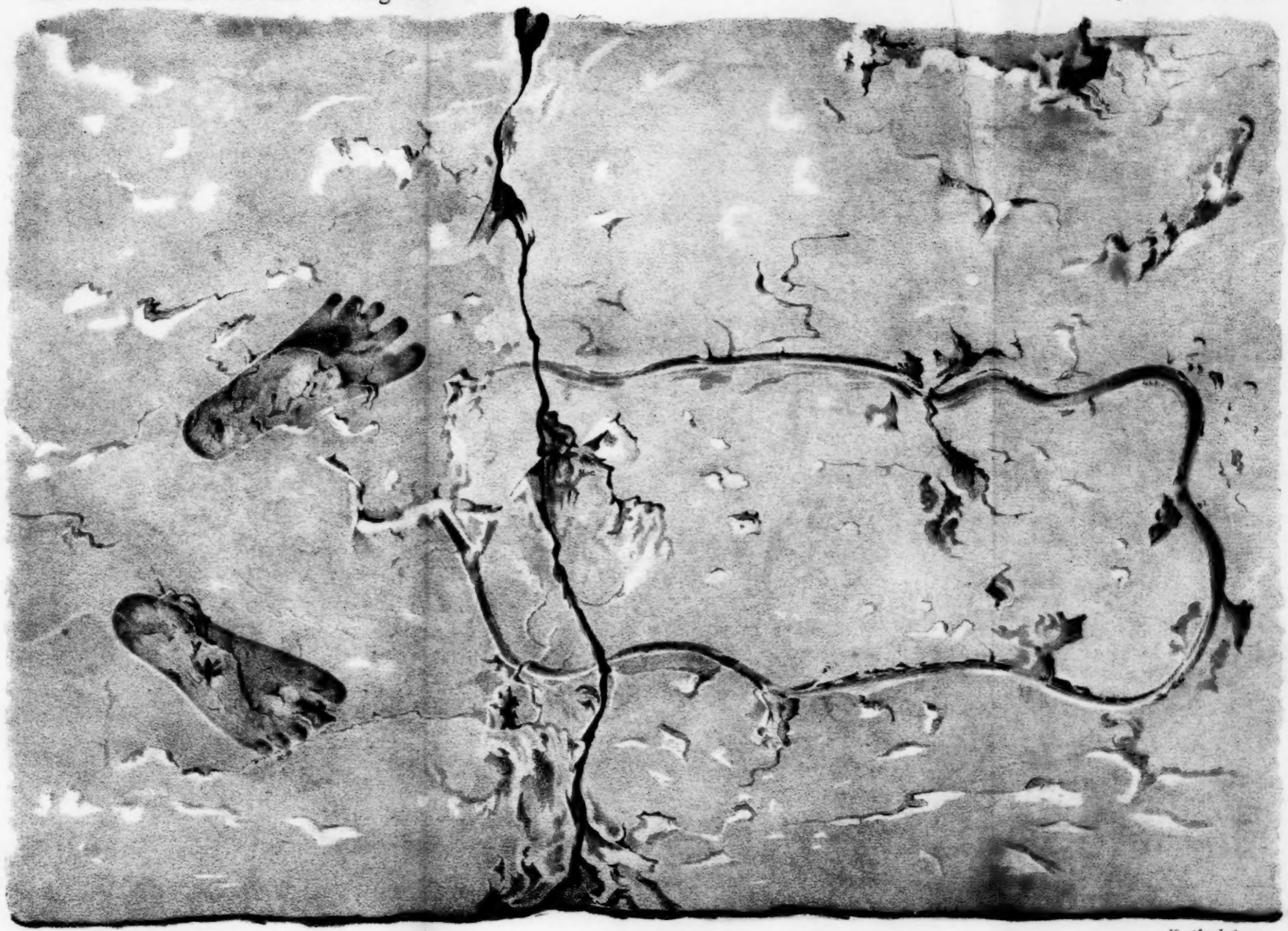
* See Vol. 1, p. 125, for an account of these mines, by John Grammer, Jr.



Lith. of E.B. & E.C. Kellogg. Hartford Conn.

Central portion of the Slab, with foot prints and scroll.

(quarried from the bed of the Mississippi, at St. Louis, in 1819.)

Mr. Schoolcraft, in the year 1822, first called attention, through the columns of this Journal,* to these impressions; the German Professor Leonhard, of Heidelberg, discusses the matter in his popular lectures, now in course of republication in this country by Prof. F. Hall; Dr. Mantell, in his "Wonders of Geology," also speaking of the same foot-prints, says that he has requested Prof. Silliman to ascertain the nature and age of the rock in which they appear; and a correspondent, in a recent number of this Journal, calls for information on the same subject.

These various observations and inquiries, and all others of a similar character which have met my eye, expressly refer to a single specimen; the only one, it would seem, hitherto discovered; namely, a slab of limestone originally found on the western bank of the Mississippi river at St. Louis, quarried for Mr. Frederick Rapp in the year 1819, and by him removed to the German settlement of Harmony in Indiana, where it became a frequent object of visit and examination among curious travellers. There Schoolcraft saw and described it; his article, above referred to, (and from which Mantell tells us he derives his information,) commences thus:

"I send you a drawing of two curious prints of the human foot in limestone rock, observed by me last summer at Harmony on the Wabash, together with a letter of Colonel Benton on the same subject. The slab containing these impressions, was originally quarried on the west bank of the Mississippi river at St. Louis, and belongs to the older flœtz range of limestone, which pervades that country to a very great extent." Leonhard, as a note by his editor reminds us, refers, also, as his sole authority, to the article here quoted, and of course to the specimen in question.

That specimen is now in my possession; and inasmuch as it has thus attracted the observation even of foreign geologists, and has given rise to not a little discussion and contrariety of opinion among scientific men, I feel called on to contribute what information I possess relative to its history and description; more especially as I have recently obtained evidence sufficiently conclusive touching its precise geological character.

The best information I can furnish in regard to the exact spot of its original location, and the circumstances by which it came

* See Vol. v, p. 223, *et seq.*

into the possession of Mr. Rapp, is to be found in the subjoined extracts from a letter written by the gentleman under whose inspection it was quarried, then a resident of St. Louis, but now of Cincinnati, Mr. Paul Anderson. This letter is dated October 11, 1841, and is in reply to one which I addressed, in the course of last autumn to Mr. Baker, Mr. Rapp's man of business, who was a resident of Harmony at the time of the purchase, and in which I had requested of him to procure for me what information he could on the subject.

Mr. Anderson writing to Mr. Baker, says:

"The letter of Mr. David Dale Owen, of the 20th ult. enclosed in yours of the 8th inst. was duly received by me here.

"Well, sir, as to the limestone slab that Mr. Frederick Rapp obtained of me sometime in 1819 at St. Louis, I will tell you its history. The year after I was located in St. Louis, during the extreme low water of the Mississippi, I was shown the imprint of human feet, that was in the limestone rock on the *very margin* of the river, and which had been only seen by the old inhabitants there very few times; as it was said by them that it was not more than once in the period of ten years or so, that the river fell to its then stage. This rock lay about opposite the centre of the city proper, and seemed to have been polished smooth by the attrition of the water. There was no rock lying on it, as it was the lower ledge of the stratified limestone that reached, by steps, to the bluff of limestone rock that ranged along the foot of the river lots of the city. This bluff of stratified rock was seemingly from ten to twenty feet high, and from twenty to forty yards from the margin of the river at extreme low water mark, all along the city. This bluff has been quarried out and a fine range of three story stone warehouses erected there on the river front. A street, too, of sixty feet wide has been laid off, besides a graduated McAdamized wharf on the outside of that again to low water mark.

"A Mr. John Jones, who claimed a sort of ownership in the rock as being the first discoverer of it *that season*, was employed by me to cut out the slab for Mr. Frederick Rapp, who was then at St. Louis on a business visit. I paid Jones (to the best of my recollection) one hundred and eighty dollars for the slab, and shipped it around to New Harmony to Mr. Rapp. Previous to its being sent away, there was an offer made of five hundred dollars for it by a "virtuoso" from some of the eastern cities;

and in consequence of this high estimate of its value, there were many of the citizens strongly disposed to prevent the slab being sent away from the city.

"I know of no rock along that margin, of a soft and plastic nature, that seemed to be in a process of consolidation; but the opinion was well grounded there at that time, that the imprint of the two human feet had been made on the rock when it was soft alluvium mud.

"I never saw or heard of any imprint of human feet along there or any where else, save on this rock; but I recollect of remarking in many of the steps of the smooth rock along near to the same place from which this slab had been taken out, the numerous imprints of turkey, deer, and buffalo feet.* I often looked to find human imprinted feet, but was unsuccessful."

These extracts fully explain the circumstances under which the slab was originally obtained by Mr. Rapp. When that gentleman, in the year 1824, sold the New Harmony estate to my father, the slab also came into my father's hands, and ultimately into the possession of the late Mr. William Maclure. After his decease, it was presented to me by his executors, and is now preserved in my museum of objects of natural history at New Harmony.

The slab itself is a ponderous mass of solid limestone, weighing upwards of a ton. Although fossils had been observed in the vicinity of its original location, yet until lately no remains had been discovered on the specimen itself. In preparing to remove it, however, from Mr. Maclure's residence to my laboratory, observing a horizontal fissure which extended entirely across the rock, I split off by the aid of wedges a continuous layer, some two or three inches thick, from its inferior surface. This operation, besides materially facilitating its transportation, disclosed, as I had hoped it would, some familiar fossil shells; and I subsequently discovered a good many more by reducing the detached

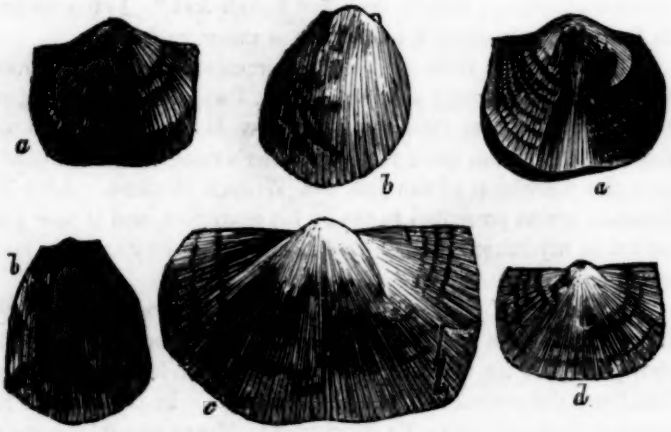
* Those unacquainted with the science of geology, frequently mistake for fossil foot-prints, what are in fact moulds of shells, or merely casual appearances. On the table-mounds in Iowa, a rock contains numerous impressions of a species of *Pentamerus*, which, when partially weather-worn, so closely resembles the print of a cloven foot as to be continually mistaken for it by the uninitiated. Hitchcock, misled by a report regarding fossil footsteps, undertook a journey of several hundred miles—to find nothing but accidental markings on the rock.

portion into small hand specimens. I was thus enabled definitely to determine the age of the rock.

The fossils obtained, proved on examination to be the same species which I had often previously observed at Leavenworth in Indiana, on the Ohio river, and elsewhere, in a rock, the exact geological position of which I had already satisfactorily ascertained. This stratum lies from ten to twenty feet below the lowest members of our true coal measures, and is considered the equivalent of the mountain limestone of Europe.

Four species of Producta, the best preserved among those obtained from the slab, are here represented, (Fig. 1.)

Fig. 1.



Producta found in the slab.

In the above plate, *a a* are the under and upper valves of a species which I have not seen described; *b b* represent the external and internal view of the under valve of another species, also, I believe, undescribed; nor have I seen *d* described; *c* resembles the *Producta Martini* of *Sow.*, but its under valve is much flatter and less distinctly striated.

I had long since felt assured, from the bearings of our geological formations, that the limestone of which these are characteristic fossils, formed the bed of the Mississippi at St. Louis; but I had not had an opportunity, during extreme low water, of making a thorough examination at that place. The discovery of these Producta confirms in a satisfactory manner my previous views.

There is but one corroborative, though not essential evidence, desirable to add to that already given in proof of the age of this rock. The uppermost bed of the group to which it belongs is a stratum of limestone of a reddish tint, and characterized by a very remarkable fossil coralline, resembling the *Retepora* of *Lin.*, but verticillated spirally like a continuous screw; described by *Lesueur* under the appropriate name of *Archimedes.** Here is a sketch (Fig. 2) of one in my possession:

Fig. 2.

Archimedes, of Lesueur.

In the same rock which contains this fossil, or in the beds immediately beneath it, which often exhibit an oolitic structure, the

* I am not sure that Lesueur ever published his description of this fossil; but I know that while he resided here (at New Harmony) he engraved a plate containing several views of it, with that intention. He considered it, I believe, a new genus; but it may be only a new species of Retepora; if so, most aptly entitled *Retepora Archimedes.*

species of Pentremite here represented, (Fig. 3,)* is also a very common fossil. Three other species have been observed in this rock: the *Pentremites ovalis* of *Gold.*, the *Pentremites florealis* of *Say*, and the *Pentremites globosa* of *Say.*† The above corallines and Crinoïdeans are peculiar to these beds. Hence I have been accustomed to designate this group of rocks here in the west, as the *Pentremital* limestone, and its upper bed as the *Archimedes* limestone. I am not aware that these organic remains have been discovered in the Atlantic states. It is upon the Archimedes limestone that our coal measures rest. Rising from beneath the great Illinois coal-field,‡ these limestone beds circumscribe it nearly in its whole extent; and wherever visible, one or other of the above characteristic fossils can uniformly be found. These fossils afford a valuable and trustworthy guide, in determining the limits of our true coal-bearing rocks; since no workable seam of coal has ever been found, either in Indiana, Illinois, Kentucky, or Tennessee, beneath the rocks in which they occur. Without doubt some one of these fossils can be discovered in the vicinity of St. Louis at low water. I shall not fail to avail myself of the first favorable opportunity of investigating this matter.

Fig. 3.

Pentremites pyriformis.

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* The Pentremites here represented, differs a little from the drawing of the *P. pyriformis* which I have seen; this specimen is much more angular or pointed where the interscapula joins the inferior extremity of the umbulacrum, and the striæ of the umbulacrum run slanting from above downwards, from the central furrow towards the interscapula, instead of from below upwards.

† A Pentremite, but of a species very different from any of these, occurs in a stratum of rock at the falls of the Ohio; the probable equivalent of the *Wenlock* formation of Murchison; the same rock described in the reports of western geologists, and popularly known here as the *cliff* rock.

‡ Delineated and described in my "Report of a Geological Exploration of part of Iowa, Wisconsin, and Illinois, made under instructions of the Secretary of the Treasury of the United States, in the autumn of the year 1839."

I take this opportunity of correcting an error with reference to this same coal-field, which has crept into a notice (in this Journal, Vol. XL, 1841) of a geological survey of Indiana, which, as geologist of that state, I had made to its legislature in the winter of 1838–9. In that notice (at p. 134) I am made to say: "Our bituminous coal formation is part of a great coal-field which includes nearly the whole of *Iowa*, *Illinois*, and eight or ten counties in the northwest part of Kentucky." It reads in my Report, "which includes nearly the whole of *Lower Illinois*, and eight or ten counties," &c. By a typographical error in the above notice which converts the word *Lower* into *Iowa*, I am thus made to say, that this coal-field extends over Iowa; while, in point of fact, only a few townships in the southern portion of that territory are included in the coal formation.

The whole Pentremital series is a remarkably pure variety of limestone. A quantitative analysis of a portion of the slab in which the foot-prints occur, gave the following result:

Carbonic acid, ...	40.80 grains.
Lime, ...	48.80
Magnesia, ...	2.60
Silica, ...	2.00
Oxide of iron and loss, ...	5.80
	100.00 grs.
Specific gravity, ...	2.67

The color of the slab has not been quite correctly given by Schoolcraft. He describes it as of a "grayish blue tint;" but, on the exposed and worn surface, it has rather a purple tint; and, when fractured, is of a very light gray. I mention this because the blue tint is by no means characteristic of this group of limestones, but is peculiar to the lowest limestones of the Ohio valley, considered the equivalent of the lower Silurian rocks of Murchison, and the Salmon river and Trenton rocks of New York, and on account of this prevailing tint, frequently described as the "*blue* fossiliferous limestones." They lie from eight hundred to one thousand feet lower in the geological series than the Pentremital limestones now under consideration.

So much for the age of the rock in which these foot-prints are found. The question next presents itself, are they true fossils, or are they the work of art?

To aid in the solution of this question, I have given (in the plate accompanying this article) a correct representation of the slab, with the foot-prints and other marks, as they at present appear. That during the twenty two years since it has been quarried, no material or appreciable alteration seems to have occurred,*

* Nor does it appear that these impressions had changed in appearance while the rock was *in situ*. I quote from the letter of Col. Benton (an eye witness) to Mr. Schoolcraft, referred to in the extracts hereinafter given from the latter gentleman's article:

"The prints were seen when the country was first settled, and had the same appearance then as now. No tradition can tell any thing about them. They look as old as the rock; they have the same fine polish which the attrition of the sand and water have made upon the rest of the rock exposed to their action. I have examined them often with great attention. They are not handsome, but exquisitely natural both in form and position; square toed, of course anterior to the use of narrow shoes."

may be inferred from the following communication from a gentleman now residing here, to whom I am indebted for many valuable additions to my geological cabinet, and who visited and critically examined the specimen sixteen years ago, in company with several distinguished naturalists:

"In reply to your inquiries regarding the now famous limestone slab with its human foot-prints, I have to say, that in the year 1826, I visited and examined it repeatedly and minutely, and have a perfectly distinct recollection of its appearance at that time. I then compared the foot-prints with my own, placing my naked foot on the impressions. They corresponded very accurately both in outline and in the depressions, answering to the principal muscles of the foot and toes, except that the toes were somewhat more widely spread than mine. Mr. Maclure, Dr. Troost, Mr. Say and Mr. Lesueur, then residents of Harmony, examined the rock at the same time. They all agreed in opinion as to the artificial origin of the tracks, with good reason, I think; for the task seems to me more easy than the fabrication of many of our native vases and other antiquities.

"I can say with confidence that there is no perceptible difference between the appearance of the tracks now and in 1826, when I first saw them; and I find that others who were then in the habit, like myself, of seeing the specimen daily, coincide with me in this opinion. SAMUEL BOLTON."

Though Messrs. Maclure, Say, Troost, and Lesueur, appear thus to have agreed as to the artificial origin of these foot-prints, yet among the various writers who have broached the subject, others have expressed a very different opinion.

Mr. Schoolcraft, in the article already referred to, and which first introduced the matter to the scientific world, expresses his unqualified conviction that they are true fossils—the actual impressions of human feet made in the rock at some remote period, when it was soft enough to receive them. Here is his description of the foot-prints, and of the rock containing them, together with his reasons for the above opinion:

"The prints are those of a man standing erect, with his heels drawn in and his toes turned outward, which is the most natural position. The distance between the heels, by accurate measurement, is six and one fourth inches, and between the toes thirteen and a half inches; but it will be perceived that these

are not the impressions of feet accustomed to a close shoe, the toes being very much spread, and the foot flattened in a manner that happens to those who have been habituated to a great length of time without shoes. Notwithstanding this circumstance, the prints are strikingly natural, exhibiting every muscular impression and swell of the heel and toes, with a precision and faithfulness to nature, which I have not been able to copy with perfect exactness in the present drawing. The length of each foot, as indicated by the prints, is ten and a half inches, and the width across the spread of the toes four inches, which diminishes to two and a half inches at the ball of the heel, indicating, as it is thought, a stature of the common size.

"This rock presents a plain and smooth surface, having acquired a polish from the sand and water, to which its original position periodically subjected it. Upon this smooth surface, commencing in front of the tracks, there is a kind of scroll, which is two and a half feet in length; the shape of this is very irregular, and not equally plain and perfect in all parts, and would convey to the observer the idea of a man idly making with his fingers, or with a smooth stick, fanciful figures upon a soft surface; some pretend to observe in this scroll the figure of an Indian bow, but this inference did not appear to any of our party to be justified.

"Every appearance will warrant the conclusion that these impressions were made at a time when the rock was soft enough to receive them by pressure, and that the marks of feet are natural and genuine. Such was the opinion of Gov. Cass and myself, formed upon the spot, and there is nothing that I have subsequently seen to alter this view; on the contrary, there are some corroborating facts calculated to strengthen and confirm it. But it will be observed by a letter which is transmitted with these remarks, that Col. Benton entertains a different opinion, and supposes them to be the result of human labor, at the same period of time when those enigmatical mounds upon the "American bottom," and above the town of St. Louis, were constructed. The reasons which have induced him to reject the opinion of their being organic remains are these:

"1st. The hardness of the rock.

"2d. The want of tracks leading to and from them.

"3d. The difficulty of supposing a change so instantaneous and apropos as must have taken place in the formation of the rock

if impressed when soft enough to receive such deep and distinct tracks."

"To those who are familiar with the facts of sea and fresh water shells, ferns, madrepores, and other fossil organic remains in the hardest sandstones and limestones of our continent, the hardness of the rock and the supposed rapidity of its consolidation, will not present objections of that force which the writer (Col. Benton) supposes. But the want of tracks leading to and from them presents a difficulty which cannot perhaps be so readily obviated. We should certainly suppose such tracks to exist, unless it could be ascertained that the toes of the prints, when *in situ*, pointed inland, in which case we should be at liberty to conjecture, that the person making them, had landed from the Mississippi and proceeded no further into the interior. But no inquiry has enabled me to ascertain this fact, the circumstance not being recollected by Col. Benton and others who have often visited this curiosity while it remained in its natural position at St. Louis.*

"The following considerations, it will be seen, are stated by Col. Benton, as capable of being urged in opposition to his theory of their being of factitious origin.

"1. The exquisiteness of the workmanship.

"2. The difficulty of working such hard material without steel or iron."

"The strikingly natural appearance of these prints, has always appeared to me to be one of the best evidences of their being genuine; for I cannot suppose that there is any artist now in America possessed of the skill necessary to produce such perfect and masterly pieces of sculpture; yet what are we to say of the skill of that people who are supposed to have been capable of producing such finished pieces of art without the aid of iron tools? For let it be constantly borne in mind that the antiquity of these tracks can be traced back to the earliest discovery of this country, and consequently prior to the introduction of iron tools

* In reply to a second letter addressed to Mr. Anderson, in order to ascertain this point, he replies, that "the foot-prints were looking *towards the east and towards the river*." Yet I do not attribute to this fact so much importance as Mr. Schoolcraft appears to affix to it. It seems to me quite as natural and likely (if we suppose but the single impression made) that an Indian should step out from his canoe backwards, and in that position shove it off again, as that he should make one step on shore, as if with the intention to land, and then step backwards again into his canoe. D. D. O.

and weapons among the aborigines. There are none of our Indian tribes who have made any proficiency in sculpture, even since the iron hatchet and knife have been exchanged for those of flint and obsidian. All their attempts in this way are grotesque, and exhibit a lamentable want of proportions; the same which was seen in the paintings and in the figured vases and pottery of the Asteecks of Mexico, when their towns and temples were first visited by the Spanish conqueror."

The learned Mantell, the distinguished geologist of southeastern England, coincides in opinion with Schoolcraft, as to the true fossil character of the foot-prints; but though he expressly refers to Schoolcraft's article, he seems to have overlooked the character of the rock; for he speaks of the impressions as being made in *sandstone*. The passage occurs in his "Wonders of Geology," already referred to, at p. 76, where he has copied Schoolcraft's drawing of the foot-prints. He says:

"In connexion with the occurrence of human bones in limestone, I will here notice a discovery of the highest interest, but which has not as yet excited among scientific observers the attention which its importance demands. I allude to the fact announced in the American Journal of Science, (Vol. v, for 1822,) of impressions of human feet in sandstone, discovered many years ago in a quarry at St. Louis, on the western bank of the Mississippi."

After giving the plate, he adds: "The above figure is an exact copy of the original drawing, and exhibits the impressions of the soles of two corresponding human feet, placed at a short distance from each other, as of an individual standing upright, in an easy position. The prints are described as presenting the perfect impress of the feet and toes, exhibiting the form of the muscles, and the flexures of the skin, as if an accurate cast had been taken in a soft substance. They were at first supposed to have been cut in the stone by the native Indians, but a little reflection sufficed to show that they were beyond the efforts of those rude children of nature; since they evinced a skill and fidelity of execution, which even my distinguished friend, Sir Francis Chantrey, could not have surpassed. No doubt exists in my mind, that these are the actual prints of human feet in soft sand, which was quickly converted into solid rock by the infiltration of calcareous matter in the manner already described. The length of

each foot is ten inches and a half, the spread of the toes four inches, indicating the usual stature; and the nature of the impression shows that the feet were unconfined by shoes or sandals. This phenomenon, unique of its kind, is fraught with so much importance, that I have requested Prof. Silliman to ascertain the nature of the sandstone, and the period of its formation."

The shrewd Leonhard, though of a country where traditions of the marvellous commonly find no little favor, is utterly sceptical in regard to this matter. His remarks are brief, and somewhat tinged with severity. He says:

"Impressions of the human foot are also said to exist in rocks of a calcareous nature on the banks of the Mississippi, in the state of Missouri. As is said, the impressions partly must have been made by a man while standing still, who, judging from the form and extended spread of the toes, could not have been accustomed to having his foot protected, and partly, there are evident marks about the impressions indicating that the feet were covered after the fashion of the Indians. The reporter of the story mentions expressly, *of course*, that the tracks are so distinct, that the impressions of the least muscle can be recognized; but this very circumstance casts suspicion on the whole narrative; and it appears probable that these marks were artificially cut in the rock. But that which excites the greatest doubt in this and other instances is, that such phenomena, until now, have occurred so isolated; the footsteps of the walking man cannot be followed farther."

With opinions so variant before me, and such names arrayed on either side of the question, it is with diffidence that I shall proceed, after describing the slab in my possession, to venture my opinion as to the probable origin of the impressions it contains.

While I cannot unite with the learned German professor in the implication conveyed by the italicising of the words "of course," in the above extract, not doubting that Mr. Schoolcraft sought faithfully to embody the impressions made upon him by the appearance of the phenomenon, yet I must be permitted to remark, that I am unable fully to endorse the unqualified expressions of admiration in regard to the matchless workmanship and inimitable fidelity of execution which the inspection of these foot-prints has called forth in various quarters. I may be supposed to regard the specimen which is the subject of these eulogiums, certainly

with no unfavorable eyes. To find myself the possessor of a fossil unique in the cabinets of Europe or America, or even of a specimen of aboriginal sculpture that should put to shame the best efforts of Chantrey's chisel, was a prospect calculated to quicken my perceptions of its merits and beauties, or to bias my judgment in favor of its genuine character. Nevertheless, after the most critical inspection, I regret to be impelled to the confession, that I see no incredible display of anatomical knowledge or artistical skill; nothing more than we may fairly attribute to the observant and ingenious Indian, dependent for his very life, as the forest warrior daily is, on an intimate and familiar acquaintance with tracks of every description, and more especially, with those of his own race. The representation is, indeed, easy and natural; at the heel, at the ball of the foot, at the outer edge of the sole opposite the instep, the impression of the muscular elevations is given with fidelity, yet without any delicate details, minute lines of demarcation between the muscles, flexures of the skin or similar minutiæ.

The appearance and dimensions of the foot-prints coincide otherwise with Schoolcraft's description of them. The greatest depth of the impression is about one sixth of an inch. The rock, as already stated, is a very compact limestone of a gray color, and its general surface has been ground down level, and even partially polished by the attrition of sand and water. The polish has extended to the impressions equally with the rest of the slab, and gives to them a smooth and finished appearance. The scroll, also alluded to by Schoolcraft, (of no determinate figure, as may be seen by the plate,) is of inferior workmanship to the foot-prints. The surface of the foot-prints themselves is somewhat broken by small superficial cracks and indentations; and deeper fissures and inequalities are distributed over the rest of the slab. It was quarried in two pieces; the fracture is shown in the drawing.

After a close inspection of the slab itself, a careful examination into its geological position, age, and origin, and a patient review of the arguments of the various writers already quoted, I have come to the conclusion, that the impressions in question are not fossils, but an intaglio of artificial origin. This opinion is based on the following considerations.

1st. Because the foot-prints are not continuous, but isolated.

2d. Because (as it would seem) this is a solitary instance of human foot-prints in solid limestone.

3d. Because of the difficulty in conceiving the sudden consolidation of compact limestone rock, after having received, while in a plastic state, such impressions.

Lastly, and chiefly, because of the age, nature, and position of the rock, and because no human remains whatever have hitherto been discovered in any similar formation.

The isolated position of our foot-prints affords a strong presumption against their fossil origin. "The footsteps of the walking man cannot be followed farther." Mr. Anderson distinctly states, that careful search has failed to detect any other human tracks in the vicinity of St. Louis. Were the tracks under consideration those of a bird instead of those of man, the fact of there being but a single pair might be accounted for under the supposition that a winged creature lit and rose from the same spot; though, so far as I know, even ornithichnites have always been found continuous; but we can hardly imagine under what circumstances a man could impress, thus evenly and naturally, a single pair of foot-prints on a soft and yielding surface, without leaving thereon other traces of his steps.

The limestone stratum containing them, is not a partial bed, but an extensive layer, necessarily deposited at one and the same time. There seems, therefore, every probability, that other foot-marks would have been discovered on adjacent parts of the rock, had those under consideration been actually made by human feet in plastic calcareous matter.

If the specimen in my possession be unique of its kind, that circumstance also is strong evidence against its fossil origin; and it would appear that it is so. Every writer, American or European, who treats of impressions of human tracks in solid rock, alludes to the specimen which forms the subject of the present article; all expressly referring to the St. Louis locality, and apparently unacquainted with any other. Yet we have already seen, that in that vicinity, none but the foot-prints in my possession have been discovered.

Until other similar impressions, or other human remains shall be found in rocks of a similar character, the presumption must remain strong against the fossil origin of these.

If, as Mantell seems to have imagined, the intaglio were in sandstone, the difficulty in supposing it a fossil would be lessened. The tracks of marsupialia, birds, and reptiles hitherto discovered, occur, I believe, uniformly in that species of rock.*

Of the materials which compose sandstone we have daily examples in a state capable of receiving an impression, and it is well known that, by the infiltration of calcareous matter, beds of sand may, in a comparatively short period of time, be consolidated. There is, therefore, not the same difficulty to encounter, in explaining the occurrence of foot-marks in sandstone as in pure calcareous matter, which, although it frequently encrusts, is seldom seen on dry land in a plastic state.

But all these previous arguments are weak, compared with that based on the origin, position and age of the rock under consideration, and on the fact, that no human remains of any description have ever been discovered in any similar formation.†

We have ascertained, that the organic remains taken from the slab itself are marine shells. We find, moreover, that it is overlaid by other beds of limestone containing fossils, also the former inhabitants of an ancient ocean. The inference is inevitable, that these various beds were deposited at the bottom of the sea. But unless we imagine the stratum containing the foot-marks to have been raised from the bed of the ocean, while still in a plastic state, to have received the impress of the human foot, and to have been again submerged, (the tracks remaining uneffaced until gradually covered by other beds of limestone,) how can we even conjecture that these prints were impressed on the nascent rock?

No remains of man or his works, have ever yet been found, except in the most recent deposits. Yet the limestone composing our slab is of immense antiquity; anterior, even, to the coal formation. Between this ancient limestone and the recent one of Guadaloupe, as well as all other rocks in which have been detected any traces of man or his handicraft, there intervene six

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* The only tracks ever discovered in solid limestone are, I believe, of Crustacea, and therefore of marine origin.

† The human fossil bones found in Guadaloupe are no exception; for they were discovered in a species of limestone *now in process of formation.* This modern rock is composed of "consolidated sand and recent shells;" the shells of the same species now existing in the adjacent seas; and bears no analogy whatever to the ancient solid limestone here treated of.

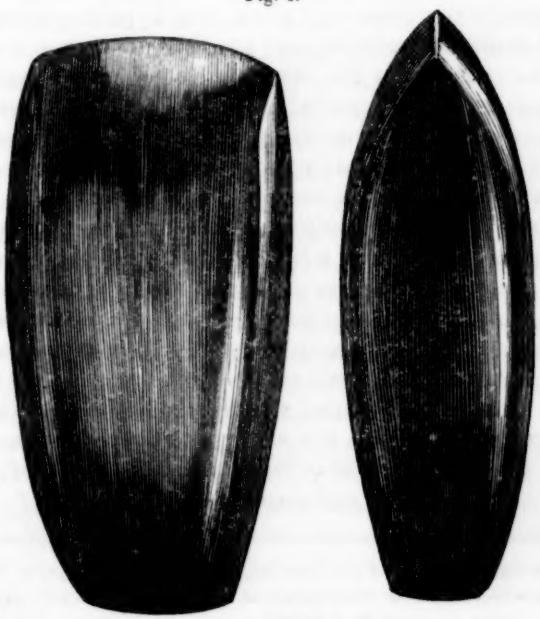
great geological formations; the coal measures; the new red sandstone; the lias and oolite; the chalk; the tertiary, and the diluvium. These deposits form a geological series commonly three or four thousand feet in thickness, and embrace six vast and strongly marked epochs, during each of which, distinct races of animals have successively arisen, existed, and become extinct. The time necessary to these changes we can hardly conceive, much less calculate. Add the supposition usually entertained by geologists (based on the gigantic and ultra-tropical vegetable growth necessary to produce the superincumbent beds of coal) that the temperature of the globe and its atmosphere during the deposition of these secondary formations, was unfit for animals with lungs; and the idea of a human fossil existing in ancient limestone must appear at variance with the best ascertained facts which the industry of the modern geologist has supplied to us, and with the most legitimate inferences to be deduced therefrom. Nothing less than some fossil phenomenon of a character so unequivocal that its origin admits of but one explanation, ought, under these manifold difficulties and improbabilities, to win our confidence or command our belief.

True, that the attempt to account for the artificial origin of these impressions is not without its difficulties. Yet of difficulties, as of evils, let us choose the least. It appears to me much less improbable that some aboriginal artist should have exhibited unlooked-for skill in intagliating a rock, than that man should have been coëval with the crustacea.

The argument deduced from the excellence of the workmanship would be more difficult of reply, did these impressions represent almost any part of the human body other than the foot. What simpler or better outline to guide the inexperienced hand of a native workman, than the mark which is left on a smooth and dry rock by a moistened foot. With such an outline as his first guide, and with the constant opportunity of testing the accuracy of the progressive work, by applying to it the naked foot, there is surely no insuperable difficulty in supposing an aboriginal sculptor, (imbued perhaps, with that inborn love and taste for his art, which we are not justified in attributing exclusively to the Caucasian variety of the human race,) to have succeeded, even with such rude tools as an Indian could command, in producing a natural and faithful representation.

The precise character of the tools which may have been employed, we cannot determine; but this seems evident; a people capable of fashioning figures of porphyry, arrowheads of flint, and mortars of granitic rocks, must have had tools capable of excavating a fraction of an inch out of a small surface of limestone. I have in my possession, an axe found amongst the antiquities of this country, wrought out of a boulder composed of hornblende and minute crystals of felspar; a rock which yields with great difficulty to the knife. This Indian relic has an admirable finish, shows not the smallest scratch or tool mark, reflects light, and is, to the touch, smooth as polished marble. I have endeavored here to represent it, (Fig. 4,) that the reader may judge of the symmetry

Fig. 4.



Indian axe, of hornblende rock.

it exhibits, the fine edge to which it is brought and the labor necessary to work so well-finished an instrument out of so hard a material. The race that could make such an axe out of a tough hornblende boulder, may well be conceived capable of engraving on a limestone slab impressions as skilful and highly finished as those before us; more especially as much of the finish observable

in the intaglio is attributable to the polishing action of the current of the Mississippi, bearing with it fine gravel and sand. This cause is alone sufficient to explain the removal of any scratches, or other tool marks of an unskilful hand, even if we suppose such to have been left by a native engraver.

We must admit the probability, that the aborigines of Northern America were unacquainted with the use of iron tools,* yet by water itself in the course of time, an impression may be made on the hardest rock. The hardness of flint is 7°, while that of limestone is but 3°. Where is, then, the improbability, that the patient Indian, who, in the intervals of war or the chase, is known to spend months in carving some favorite weapon or frivolous ornament, should have gradually hollowed out these foot-prints? How incomparably easier such a task, than to produce those complicated ornaments on altar-pieces and idols in Central America, which the enterprise of Mr. Stephens has recently submitted to the inspection of the curious? The Western hemisphere once produced its sculptors, persevering, skilful, even tasteful and delicate. If they have left their handiwork in Guatimala and Yucatan, why not also on the banks of the Mississippi.

The slab which is the subject of these enquiries was quarried, it will be recollected, from a ledge of rock at a point on the very edge of the stream when at its lowest stage. The present site of St. Louis, it will also be borne in mind, was a common gathering place of the neighboring Indians, as the adjacent mounds abundantly testify. May we not, then, with some degree of confidence, hazard the conjecture, that our impressions were an aboriginal record of extreme low water, as observed by the Indian race, at their favorite resort on the banks of the Father of Waters —their own unequalled and magnificent *Me-scha-si-pi?*

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* Yet it is possible that our specimen might have been chiselled by the aid of iron or steel tools. Neither tradition nor its present appearance may justify us in positively dating its origin back beyond a couple of centuries. But Bancroft, in his History of the United States, reminds us, that Soto and a party of Spaniards ascended the Mississippi above New Madrid in the year 1541; and dispatched an exploring party to examine the regions farther north. This or some other party—perhaps some of the persevering Jesuits, who at a very remote period penetrated these wilds—may have reached St. Louis at that early day, and introduced iron tools among the Indians. Nay, it is within the bounds of possibility, though certainly improbable enough, that some of these adventurers themselves were the sculptors.

Art. III.—*On the Identity of Pyrochlore with the Microlite of Prof. Shepard;* by J. E. Teschemacher, and A. A. Hayes.

Read before the Chemical Society of Boston, March 14, 1842, and communicated for this Journal.

Feeling confident from a close examination of several crystals of the mineral named Microlite by Prof. C. U. Shepard, which I obtained from Chesterfield, Mass., the locality mentioned by him, that it was identical with the Pyrochlore discovered by Otto von Tauk, examined and named by Berzelius, and found in several European localities, I handed to Mr. A. A. Hayes about one and a half grains of selected crystals, which at the request of this Society he kindly undertook to analyze.

Below is the result of his analysis, as also that of Pyrochlore by Wöhler; it will be seen fully to confirm my conjecture. I have therefore merely to add, that I found crystals varying in color from transparent straw-yellow to brick-red and dark black, as might be expected in a mineral, several of whose constituents are probably mechanical mixtures; the transparent and smaller crystals, being beautifully modified, as described by Shepard, on the solid angles and on the edges of the octahedron. The largest crystal I found was that exhibited at the last meeting of this Society, and which if extracted from the green tourmaline in which it is imbedded would probably weigh three grains; it has modifications on the edges.

Analysis of the Microlite, by A. A. Hayes.

Pyrognostic characters.—The surfaces of the fractured crystals of this mineral, present an inequality of texture, indicating a mixed composition. The colors are also irregularly distributed, and vary from light yellow to clove brown. When heated in a tube, a small quantity of aqueous vapor appears, having an empyreumatic odor; as the vapor escapes, a translucent fragment of a clove brown color and glassy lustre becomes opake and of a fine canella color, with pearly lustre. In the forceps and exposed to the outer flame of the lamp, the edges of a fragment fuse into a canella colored enamel, which in the reducing flame becomes darker, and finally of a clove color. The outer flame re-

stores the brown color again; these changes constitute a distinctive character. With borax on a platina wire, the mineral fuses with slight effervescence, the outer flame gives a glass which while hot is reddish brown, but becomes pale yellow as it cools; the globule in the reducing flame remains clear, and when cold is of a pale green color, when flamed a white enamel is produced. The darkest colored fragments give a yellowish enamel, but the reducing flame gives as before a light green glass. With a particle of oxide of iron the borax globule in the reducing flame gives the characteristic reactions of ferruginous titanic acid.

Phosphoric salt gives in the outer flame a reddish yellow glass whilst hot, which becomes green on cooling; the reducing flame gives a clear fine green glass. Tin does not develope the color of titanic oxide. Soda does not show the presence of manganese, but the mineral gives a deep green color to the fused mass while hot, which becomes yellowish brown on cooling. One grain of the mineral which had been dried was decomposed, the titanic acid carefully separated and dried, it weighed 80; this had the chemical characters of pure titanic acid.

The solution of the oxides from the titanic acid gave a precipitate of sulphate of tin, when treated with sulpho-hydric acid, and the sulphate oxidized before the blowpipe gave with soda a globule of tin. Sulpho-hydrate of ammonia gave a black precipitate, which when roasted contained oxides of iron and uranium, with traces of oxide of cerium. The fluid remaining gave with oxalate of ammonia, a precipitate which was converted into sulphate of lime, equivalent to 0.08 lime. Thus,

Titanic acid, ...	80.
Oxide of tin, iron, cerium, uranium, ...	11.8
Lime, ...	08.2
	100.0

This mineral is therefore identical with that analyzed by Wöhler. The absence of protoxide of manganese and water, and the smaller proportion of oxide of iron in this specimen, as indicated by the blowpipe experiments, will account for the larger proportion of titanic acid given in the analysis.

Analysis of Pyrochlore, by Wöhler.

Titanic acid, ...	62.75
Lime, ...	12.85
Protoxide of manganese, . . .	2.75
Oxide of iron, ...	2.16
Oxide of uranium, ...	5.18
Oxide of cerium, ...	6.80
Oxide of tin, ...	0.61
Water, ...	4.20
Fluoric acid and magnesia, . .	traces
	97.30

ART. IV.—*On the Wisconsin and Missouri Lead Region;* by JAMES T. HODGE.

THE following observations upon some of the mineral resources of Wisconsin and Missouri, were made in the course of a tour through parts of the western country the last season. My attention having been directed by the company by whom I was employed, to ascertain the probable importance of a few mines only, I was unable to devote much time to the elucidation of the general geology of that country; this I am happy to see in the last number of the American Journal, is taken up by one well able to connect its formations with those of our eastern states.

This region, according to Messrs. Owen and Locke, comprehends sixty two townships in Wisconsin, eight in Iowa, and ten in Illinois, its extreme length from east to west being eighty seven miles, and width from north to south fifty four miles. Though the "cliff" limestone, the rock formation that contains the lead ore, occupies a greater extent of country, it is in this portion only that circumstances seem to have been favorable for the production of fissures containing the ore. This rock is not broken through by granite or other rock of igneous origin, as the limestone of Missouri is, that there produces lead ore; and its calcareous character is more constant than this, which frequently passes into a true siliceous rock. Its strata appear uniformly

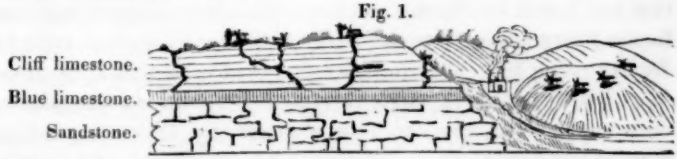
horizontal, until by tracing them some miles, a prevailing dip to the south is discovered.

The lead region is a rolling hilly country, the hills sometimes covered with an open growth of oak, but as often entirely free of timber, and clothed with the tall prairie grass only. The summits maintain a general level, except where it is broken by the "natural mounds," (the two Blue mounds, the Platte mounds, Sinsinava mounds, &c.) which rise several hundred feet above it. In these the limestone appears more siliceous than is noticed elsewhere, and its superior hardness may in part have been the cause of these mounds remaining like monuments of the devastating currents that must have given the surface around its present form; while the huge blocks, tipped out of their horizontal position, lie on the steep sides as additional evidence of the wasting waters. Yet these are the only evidences that such a force has been in operation; for in the western part of Wisconsin, there are no primary bowlders, no loose rocks but those which once evidently formed a part of the formations on which they now repose; in the eastern part of the territory, however, and to the west in Iowa, such bowlders are not wanting. Whether this region may have been in part protected by the high lands to the north of it, and the progress of the bowlders been thus intercepted and turned aside, must be determined by more extended observations. This supposition is rendered more plausible by the unusual course of the Wisconsin river, it suddenly turning from a south to a west direction. In its valley, however, where it flows towards the west, no bowlders are found except the small pebbles brought down by the river itself.

Throughout the extensive tract defined as the lead region, lead ore may be sought for with prospect of success on every township and on almost every square mile. And fortunately it is so well watered, and the little streams have so rapid a fall, that power for furnaces may almost always be obtained near the mines. New discoveries are continually made, and with every one further light is thown upon the true character of the ranges of fissures containing the lead and copper ores; by which result they can be traced with greater certainty from one tract to another, without depending entirely on the present imperfect system of "prospecting."

Beneath the cliff limestone is a thin stratum of blue limestone, and this rests on a body of brown sandstone. As one goes from the southern townships of Wisconsin towards the north, this blue limestone is observed to become higher and higher in the hills, and the lead diggings to be every where above it. Though the sandstone rocks come out in bold bluffs on the sides of the hills, no veins of ore are ever found in them; but in the cliff limestone above, they are found, though the rock and its fissures lie hid under a great depth of soil. The section annexed (Fig. 1) represents this order of superposition, the character of the fissures, and about the relative proportion that the three rocks bear in the hills near Mineral Point.

Fig. 1.



These fissures are of every degree of width, from fifty feet down to thin cracks; all of them do not contain ore; the large chambers, when they have any mineral in them, are lined on the walls with a coating of lead ore, seldom over a foot thick, while the interior is filled with clay. Sometimes across the crevices run horizontal layers of galena; and again it occurs in loose "chunks" in the clay of the fissures or of the soil above, and again it runs in a vertical sheet down, or still again filling narrow fissures in the appearance of a vein and of a bed in the solid rock. But the lead is not the only ore these fissures contain; mixed with it in every proportion, and even sometimes getting the better of the galena and shutting it out completely, occur both the carbonate and sulphuret of zinc; the one known to the miners by the name of "dry bone," the other "black Jack." From the abundance of the carbonate of zinc, and its being an ore that when clear yields about 60 per cent. of the oxide, it seems probable that it will sometime become an object of importance; now it is considered a great obstruction whenever met with, and the galena when mixed with much of the zinc ore, brings an inferior price.

The direction of the fissures downwards is as variable as their size and shape. They run like cracks through a rock—sometimes vertically, sometimes inclined, and sometimes horizontally

between the strata. But in all cases on reaching the sandstone, they are, as far as is yet known, unproductive. They are followed when they are found to yield three inches of galena, that being the least vein it is thought worth while to pursue through rock; and it is very rare indeed that a continuous vein is found exceeding one foot in thickness. The horizontal direction of the fissures is more uniform; those producing the most ore almost universally running nearly east and west. Near Mineral Point, some fissures running north and south produce good ore, but they are for the most part horizontal beds (of limited width) between the strata, and out of these directions it is rare to find a productive fissure. The smelters think they can distinguish the ores that are found in different fissures—that from an east and west fissure being perfectly crystallized, of a smooth surface, striæ indistinct; that from a north and south fissure, of crystalline structure, with two sets of striæ very distinct, crossing each other at right angles; and the ore from a quartering fissure crystalline, with many sets of striæ crossing each other obliquely; and to some extent I had opportunity of proving their observations correct. The fissures appear to be limited in length to within a few hundred feet, and to lie in ranges which extend at right angles with the direction of the fissures. In the neighborhood of Mineral Point many of these fissures are opened and mined, and the "diggings" are seen to extend with little irregularity in a north and south belt, that part to the west producing lead ore; half a mile to the east the fissures containing copper ore, and still further east a mile or more, hematite iron ore abounds in them.

The deepest shafts that have been sunk on these fissures are about ninety feet; and at Mineral Point they may be worked to that depth without the water being troublesome. But as these deep shafts were sunk on the highest ground, the bottom of them hardly reaches the sandstone.

Copper Ores.—The copper ore is similarly situated to the lead ores, either in wide fissures or in thin veins running through the rock. As many as four of the little veins not exceeding two inches in thickness have been found running about east and west on different parts of the mining ground. The ore in these is a mixture of the sulphuret and carbonate. Besides these, which are not considered important, there is a large fissure, in places fourteen feet wide, that has been traced about a quarter of a mile.

It is on the old Ansley tract, and extends in a westerly direction towards Mineral Point. For about the depth of fifteen feet the fissure was found to be filled with "gossan" and lumps of sulphuret and carbonate of copper mixed in it. Below this depth is clay with a little ore scattered through it. The lumps above were of all sizes up to two hundred pounds weight. No shafts were ever sunk to prove this fissure at greater depths; but there is every reason to suppose that it will be found productive in other parts beside the strip near the surface. The little rock veins prove that the ore belongs to the formation as much as the lead ores, and in whatever way it may have been brought up from below, it is likely to have formed other deposits in the fissure worth looking after.

In the report of the geology of Cornwall, Devon and West Somerset it is remarked that "the per centage of cases is considerable when an iron ochreous substance named gossan prevails, and copper ore is connected with it, and it may be said that the instances are very rare where copper ore is found in fair quantity in a lode, without gossan having been discovered on the back or upper part of that lode." p. 326.

The sandstone lies at about the depth of one hundred feet below, and although in it we are not to expect to find the fissures or cracks (if they have dwindled to them) productive, still there is sufficient room above for a large supply of ore. It is said that 1,640,000 pounds of ore (probably including unwashed and gossan) have been raised from this fissure; 50,000 pounds were sent to England, and 100,000 pounds are now on the bank of the Mississippi River at Sonapee; 620,000 pounds have been taken to the old furnace, and the little one at New Baltimore, and between 500,000 and 600,000 pounds remain now on the surface at the mines. This is evidently a very rude estimate. It is also said that the ore sent to England yielded twenty per cent. of copper; at any rate, however, it brought in a bill of expense. Were the ore well washed from the clay and iron ore mixed with it, and the lump ore carefully broken up and washed, there is no reason to doubt that it may be smelted with profit; but all the operations so far have been badly conducted. There was no uniformity in the quality of the ores used, no judgment exercised concerning the quality or quantity of flux, and the smelting was carried on in furnaces that must be blown out every twenty four

or thirty six hours, in order to put in a new lining, the sulphurous vapors and strong blast soon destroying the back wall. In this manner I saw some copper smelted in a furnace at New Baltimore, which, as they said, cost only ten dollars! The high price of fuel would render a reverberatory furnace expensive, particularly, as the ore would then be first roasted. This is now neglected, the ores being run down at once in a little blast furnace. Whether successful experiments with these ores might not be conducted by making the throat of the furnace flaring, that the ores might have time to become partially roasted before getting down into the smelting heat remains to be proved. Though the English methods may be the most perfect for smelting the ores clean, I believe they will not be found the most expedient in Wisconsin.

It is difficult to form any correct judgment concerning the per centage of these ores, particularly the gossan, for they are continually changing their relative proportions of copper, iron and clay, so that a few analyses would not decide the matter. According to the report of Dr. Owen "three *average* specimens" of the lump ore yielded respectively 23, 24⅛, and 35.7 per cent. of copper; and in the same report he says that the gossan yields by analysis from six to nine per cent. of pure copper.

In this uncertain state of the value of these mines, it would not seem advisable to make much outlay in working them; still as a furnace may be built in connexion with lead furnaces without much extra expense, and whether the copper business succeeds or not, no great risk will be incurred—and also as the miners are disposed to take upon themselves the risk of proving the mines, provided they are insured a market for the ore at prices agreed upon, according to its quality, between themselves and the smelter, they certainly are worthy of attention, and authorize a cautious investiture of capital to prove the business.

Some additional encouragement is afforded from the fact of other discoveries of copper ore having been made in the territory, though none of them have yet proved to be important. I saw one of good quality from the Blue River country, and visited a mine, a thin rock vein, near the Peccatolica, about five miles north of the Illinois line.

In this neighborhood I discovered some fire clay apparently of excellent quality, which may be of no little importance in making

fire bricks for linings for the furnaces. It is an alluvial bed six feet thick, at Winslow on the Peccatolica, where it crosses the state line.

Account of the lead business of Wisconsin.—The lead ore is sought for by the miners at their own risk. Wherever they think there is a prospect of discovering a "lead," there they commence their operations; two of them joining to sink experimental shafts. Sometimes they spend a year in unsuccessful exploring, but with the expectation of being repaid for it all by a happy discovery. If they strike a "lead" they offer the ore to the nearest smelters at the market price, and the owner of the lead comes in for his share of one fifth of the ore raised, but the original discoverers are allowed by the custom of the country the other four fifths. Should the discovery promise to be an important one, other miners are attracted to it from the country around. They come in companies proportioned to the reputation the new diggings have acquired, and in a month's time a little village of log cabins with a population of three or four hundred people has sprung up in the midst of what was just before wild woods or an uninhabited prairie. The new comers not having been instrumental in making the discovery, have an inferior claim to their predecessors, who are not permitted by "the rules of the mines" to monopolize more than a certain number of square rods around their successful shafts. As each one comes, he selects his own ground, and so many rods are staked out for his operations, but of the ore he raises, *four* fifths go to the proprietors of the land, and he is allowed but one fifth. The proprietor may persuade miners to come and work in this way, or he may hire them on fixed wages, but the former is considered the preferable plan, because the miner is induced by it to raise as much ore as possible, and in the latter it is no object to him to take out any at all, and it is therefore frequently the case that when working on wages they will carefully conceal a rich lead, and work in unprofitable rock until the proprietor abandons the diggings, and years perhaps have passed, when they will come back and make a new discovery there, and work it on shares. The miners sometimes sell their "prospect," while it generally comes into the hands of the proprietors, who then receive their greatest share of four fifths, or it is bought by other miners, who are entitled to the same privileges as the original workmen. All mineral raised

on government land should by law be subject to a tax of ten per cent., paid in lead by the smelters, and the lands are not subject to entry. But since the year 1835 none of these dues have been collected, though a government superintendent has always been appointed for this purpose, and now no attempts are ever made to collect the ore rents, neither are any questions asked at the land offices whether or no the lands about to be entered are known to contain mineral. It is generally believed that a law will be passed taking off all restrictions on mineral lands, both as to entry and subsequent claims for ore rents.

The smelters are for the most part, a distinct class from the miners. They are men of a little capital, who expend it in establishing one or more furnaces in what they judge a suitable locality, both for convenience of water power and proximity to mines that promise to be permanent in their supply of ore. Their business is to visit the mines, and every day bargain for so much mineral, sometimes of one set of miners, sometimes of another. The ore is weighed out by the miners, the smelter sends his teams for it, and has it weighed again at the furnace. The price fluctuates with the price of lead, with the greater or less amount of competition, either among the smelters or miners, and varies with the distance from the shipping port, which is now Galena in Illinois. As the smelters generally have no capital to spare, they must either sell their lead as they make it for what it will bring, or if they ship it themselves they are compelled to cease their operations until they receive their returns, for they are obliged to pay for their mineral in cash, to secure the good will of the miners, and it may be ten months before they receive the proceeds of their lead sent to the Eastern market. On this account, and from the unsteady character of the miners, who wander about, as their fancy directs, from place to place, there are few furnaces that keep in blast for a great length of time; they go for a week, or a month, or six months, and stop as irregularly. No supply of mineral is ever bought up when it is low, though lead is often kept stacked up, waiting a higher price, and the furnace out of blast for want of means to buy more ore.

The furnaces are much improved within a few years past. The ore was formerly melted down on log heaps and a small portion of the metal thus extracted at a great waste of fuel. Now they are of the most approved forms and constructed with par-

ticular regard to the most economical methods of smelting as to fuel and labor. They make use of the *reverberatory* furnace with its modification, the *cupola*, the *blast* furnace and the *slag* furnace.

The *reverberatory* is much like the common reverberatory furnace for puddling iron and smelting other ores. The ore is supplied either through a hopper on the top, or through the holes on the sides, which serve also for admission to the pokers used for stirring up the charge. The hearth is covered with old cinders beaten up, and it inclines back from the fire, so that the metal runs out at the end, under the chimney. In England where these furnaces are extensively used they are supplied with bituminous coal for fuel, but here they must make use of wood, and from the great consumption of it this class of furnaces is only resorted to where wood is of little value, and water power cannot be obtained.

Another objection to them, besides the consumption of fuel, is that they do not smelt the ore clean, the slag being nearly as rich as the ore originally was; and it is therefore necessary to have a slag furnace connected with them. It is supposed from rude calculations that an ore worth about eighty per cent. will yield in a reverberatory about sixty five, and that the slag produced will contain from thirty to forty per cent. of lead. The following is an estimate of the working and produce of O'Neill's furnace, about two miles south of Mineral Point. It is worked eighteen hours out of the twenty four by two shifts; each shift, two hands. The charge varies from 9,000 to 12,000 pounds of ore, it sometimes requiring three, sometimes four charges of 3,000 pounds each, according to the poorer or better quality of the ore. The consumption of fuel is about two cords a day, and the produce is from seventy five to eighty three pigs a day of seventy pounds average weight. The two head smelters' wages, fifty dollars per month each; two back hands twenty five dollars, and the board of them all beside. The average price of ore is probably about the price it was selling for at Mineral Point in September, fifteen dollars per thousand pounds; lead was then worth at Galena three cents per pound.

Estimate of Expenses of Reverberatory Furnace.

Wages per month, as above, $150. Board four hands four weeks, $48, ...	$198 00
Ore 10,500 lbs. daily for 26 days, at $15 per 1000 lbs.,	4095 00
Wood, 52 cords, at say $2, ...	104 00
Hauling ore to furnace, 273,000 lbs. at say 75 cts. per 1000,	204 75
Hauling lead to Galena, 79 pigs daily, at 20 cts. per 100,	287 56
	4889 31
Worth of 2054 pigs of lead at Galena, . . .	4313 40

Besides this produce is the amount of slag made, of the value of which it is impossible to make a correct estimate. The only way perhaps by which we may approximate it, is as follows:— Supposing the ore originally to be worth 75 per cent. of lead, the 273,000 pounds then contain 204,750 of metal, of which 60,970 are missing; allow ten per cent. for loss in the furnace, (escaping in fumes of the oxide and sulphate of lead,) and there remain 54,873 pounds of lead, which must be in the slag. Taking average pieces of this slag, which consists of a mixture of pure lead, unaltered galena, sulphate of lead, and earthy matters, grinding them thoroughly, and submitting portions of the powder to analysis, fusing one portion with carbonate of soda, and digesting another many days in dilute nitric acid, and then fusing the insoluble remainder with dry carbonate of soda, I obtained the following result, neglecting the sulphur and sulphuric acid:

Silica, ...	15 per cent.
Sulphate of lead obtained by the action of fuming nitric acid on the sulphuret, precipitated by hydrosulphuric acid, gave lead, .	34.30 "
Peroxide of iron, ...	24.53 "

The 54,873 pounds of lead require therefore 160,000 pounds of slag, when this contains 34.30 per cent. of lead. It seems a fair allowance that this should be worth one third as much as the original ore, or $5 per 1000 lbs. = $820. Adding this sum to the value of the lead made, we have $4313 40 + $820 = $5133 40

From which deducting the expenses, . .	4889 31
Leaves as the profit per month, ...	$244 09

This estimate gives a small return for the amount of capital employed, but it must be observed that it is made out under the

worst circumstances in which a smelter can be placed; for without considering the highest wages that are paid, high board, and the heavy item of hauling ore, which may be much diminished with the distance, suppose ore to be raised on land owned by the smelter, discovered by others; he saves at once $829, and his monthly profits increase to $1,063. Suppose him to have made the discoveries with his own hired miners on his own land, and he then saves $3,276, making his profits for the month, $3520. But this calculation is made rather to show what *might* happen than what has, or is likely to. It is one of the chances of the business in which to some extent, several smelters have been fortunate; but for the most part they would be glad now to obtain half the ore they require, off their own lands, as the result of the discoveries of others.

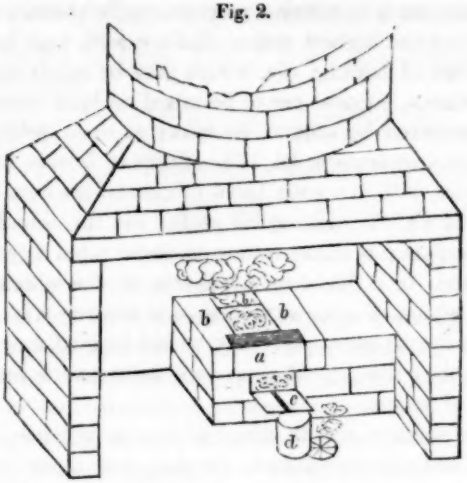
The *blast* furnace is like those of the same name in general use in England; though coke is the only fuel there supposed to be suitable for it, charcoal has here been found equally good and is in general use.

The following sketch (fig. 2) will give a general idea of this furnace, and a minute description of its parts with working sections may be seen in Elié de Beaumont's "Voyage Metallurgique, &c." The blast is raised by the simplest machinery—a crank on the end of the axle of the water-wheel working either the common double bellows or the cylindrical bellows; while another pair is often connected with the same wheel to blow a slag furnace or a copper furnace, as at New Baltimore.

Three hands at a time are required to work this furnace; the head smelter, whose duties are not quite so arduous as those of the head smelter of a reverberatory, and whose pay is not so high; a "back-hand," who assists the smelter by throwing in charcoal and wood and ore after he stirs the fire, and an assistant who prepares the materials. They work one shift which ends when thirty pigs are made, and this requires from eight to ten hours. Then another set of hands come on and work another shift. Some smelters however, employ but one set, still their day's work is over when the thirty pigs are run.

The process is this: a fire is made in the morning of billets of wood carefully arranged in the fireplace, the blast is put on, and charcoal added, as the wood burns away; ore is then thrown on in small quantity, together with a little lime. The ore has first

Fig. 2.



a, Cast iron plate in front of the fire.
b b, Cast iron blocks forming the sides and back of the fireplace.
c, Sloping hearth down which the melted lead runs into the pot.
d, Pot to catch the metal.

Across the whole front,	11 feet 6 inches.
Depth,	8 " 9 "
Height of furnace,	2 " 8 "
Width of fireplace,	1 " 7 "
Depth, " "	1 " 9 "
Height above hearth,	1 " 4 "

been prepared by breaking it up either with a hammer or between a pair of cast iron rollers, into pieces about the size of pigeon's eggs, and if mixed with much clay, it must also have been washed in a stream of water. It is allowed to remain a few moments on the surface of the fire, while a part of the sulphur is burnt out and carried off, in part combined with the oxygen, supplied in large quantities by the blast, which comes in from behind through the fire. When the mass begins to melt and becomes consolidated, the head smelter with a long iron bar pries up the whole body, working under the iron plate in front of the fire; he then finishes the operation by similar stirring above, and as he opens the mass the back-hand throws a handful of billets of wood under the whole, against the back wall and the tweer, and immediately adds more charcoal and more ore. This remains on the surface a few moments and then the same operation is repeated, and so on. When the material clogs up and forms lumps, they are beat-

en and broken with the shovel or poker. The little slag which is produced is thrown up in the corner of the furnace, to be broken up and mixed with the ore, or reserved for the slag furnace. It is important neither for its quantity nor its richness, this method of smelting being found very effectual in reducing the ore. The metal soon fills the basin at the bottom of the fireplace and then runs out down the groove in the sloping hearth in front into a pot, where it is kept in a melted state by a fire of chips under the pot, and is ladled out into moulds whenever convenient. The whole inside of the fireplace, is lined with heavy blocks of cast iron made for the purpose, and generally brought down the Ohio river. Considerable skill is requisite in managing the fire, and it is only by long practice that one learns the true method of stirring up the charge, so that the metal shall run freely and steadily. The lime is supposed to act as a flux, but very little however is used, a handful or so being thrown on at each stirring.

The following are two estimates of the expense of working one of these furnaces. Being made at different furnaces, they will be seen to differ somewhat.

Expenses of blast furnace, two shifts.

Two smelters, $1 54 per day, . . .	$3 8
Two back hands, 78 cts., ...	1 56
Two assistants, 69 cts., ...	1 38
Fuel, 20 bbls. charcoal, 12½ cts., wood, 50 cts.,	3 00
Board, six hands, 35 cts., ...	2 10
Ore, 6000 lbs. $15, ...	90 00
Hauling ore, ...	3 00
Hauling 4,200 lbs. lead to Galena, . .	12 60
Daily expense, ...	$116 72

The hauling to Galena need not be more than 80 cts. per 100 lbs., $8 40 instead of $12 60, making a difference of $4 20. The charcoal may be made for less on one's own land, and one fifth of the price of the ore might be saved if the whole was mined on one's own land; four fifths of the discovery too was the proprietors.

Product, 4,200 lbs. worth $126.—Slag worth ——.

Expenses of blast furnace, one shift.

One smelter, ...	$1 15
Two assistants, 57½ cts., ...	1 15
Fuel, 8 bbls. charcoal, 12½ cts., wood, 50 cts.,	1 50
Board, three hands, 50 cts.	1 50
Ore, 3000 lbs. $15, ...	45 00
Hauling ore nine miles to furnace, 75 cts. .	2 25
Hauling lead to Galena, 2,100 lbs., . .	4 20
Daily expense, ...	$56 75

One fifth ore rent saves $9. Hauling the ore and board may be much less. The wages as estimated, are lower than workmen can generally be employed for.

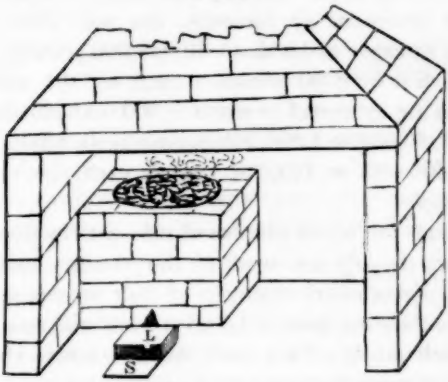
Product 2,100 lbs. worth $63.—Slag worth ——.

From both these estimates, it will be seen that the amount of lead obtained from the ore supplied is seventy per cent. Ten to twelve per cent. then is lost, and remains in the slag. The walls and front of the furnace are always covered with a thick incrustation of oxide and sulphate of lead, and much more goes off in the white smoke, all of which might be saved were it an object.

In estimating the importance of this business, it must be taken into account that it is not always an easy matter to keep *one* furnace supplied with ore, much more several. And on the other hand, that the returns for the sale of the lead are at the price it bears at Galena with the merchants there, who make their profits by shipping it to the eastern market.

The slag furnace, of which a drawing is given on the next page, (Fig. 3,) is often connected with a blast furnace or a reverberatory, particularly when the smelter can obtain any of the old slag from the now abandoned "ash furnaces" to mix with what he makes. At some furnaces the slag is beaten up under stampers and washed through a series of vats, but generally it is merely broken by hammer into small lumps, and then thrown into the furnace. The principle of the slag furnace differs from that of the blast furnace, in which the ore is exposed to the greatest oxidizing action to be obtained; the object being thoroughly to melt the slag and keep it in a fluid state until the metal separates itself, and both run out together through the hole in front. The lead sinks

Fig. 3.



Furnace about four feet high, four feet deep, and five feet front.
Tweer introduced from behind, opposite the hole for the exit of the lead and slag.
Fuel—charcoal.
L, vessel to catch the lead.
S, hole to catch the slag; in this runs a current of water.

into the first vessel, the slag floats over it into the next, through which runs a stream of water. Here it is cooled, and then ladled out and thrown away.* The amount of lead produced by one of these furnaces, varies of course with the quality of the slag. At O'Neill's slag furnace on the Peccatolica, near Mineral Point, where the charge consists of the rich reverberatory furnace slag, and that from the old ash furnaces, twenty seven pigs of lead are frequently obtained at one shift or day's work; twenty five, however, are considered a good day's work. The hands employed, are a smelter, back-hand, and assistant.

Having given this particular account of the furnaces, I will now enter into an examination of the lead business taken as a whole; and most of the data for the estimate I shall take from the report of Dr. Owen.

The whole number of furnaces in Iowa, Illinois, and the territory of Wisconsin, he judges to be fifty. This was in the year 1839, since which there has been no great variation in the busi-

* It is supposed this glassy slag is nearly free of metal; but having analyzed it by digesting in nitric acid, separating the silica, throwing down the lead as a sulphuret by hydrosulphuric acid, and converting this into sulphate of lead, I found it to contain 24.72 per cent. of oxide of lead.

ness. Four are in Iowa, and about as many in Illinois. About sixteen are reverberatory furnaces, the rest principally blast. These fifty furnaces make about 30,000,000 pounds of lead annually, which is 600,000 pounds to each on the average. But six of them are estimated to make 1,000,000 pounds each, and four from 1,260,000 to 1,502,200 pounds each, while seven make only from 400,000 to 194,610 pounds each, the least made by any one furnace.

He estimates the whole number of miners to be three thousand, but considers they do not work on the average more than half their time. From many examples of their success in mining, he says, "it would seem then to be a very low and safe estimate, to calculate each miner's daily work on the average at 150 pounds of ore. Now supposing that of the three thousand miners estimated to be at work in the district, one third are engaged in 'prospecting,' and other unproductive preparations, and only two thousand actually employed in raising ore, and that these two thousand work only one hundred and fifty days in each year, we have the following result. Each miner will raise annually 22,500 pounds of ore. The two thousand miners will raise annually 45,000,000 pounds of ore, and this at 70 per cent., which is rather below than above the average yield of the galena of this district, will give 31,500,000 pounds of lead as the annual produce of these mines."

So far goes the calculation of Dr. Owen; from it and from a number of instances of miners raising a large amount of ore in a short time, and of small tracts proving wonderfully productive, he draws a vague conclusion of the unbounded richness of this region, and of the profits to be derived from the business. But I propose to carry out these estimates and see the results.

Allowing that 45,000,000 pounds of ore is the annual yield of the mines, and dividing this according to customary shares between the miners and smelters, we must allow to the former 530 pounds of *lead* for every 1000 pounds of ore, for in this way they often take their pay for the ore, receiving from 520 to 540 pounds of *lead*. The mean 530 is equivalent to 757 of ore; it is divided then as by the following calculation.

757
45,000,000

3785,000
3028

34065,000 miners' share of ore.

10935,000 smelters' share of ore.
70

7,654,500
3

50)229,635,00 value.

$4,592 70 each smelter receives after paying for his ore.

34,065,000
70

23,845,500 lead.
3

3000)715,365,00 value.

$238 45 each miner receives annually.

To ascertain the other expenses of each furnace in making its share of the 31,500,000 lbs. of lead, we divide this amount by the number of furnaces, by the pounds to the pig, and the number of pigs that may be made in a day, to get the number of days, as 31,500,000÷50÷70÷60=150.

The daily expenses, according to the two estimates of the blast furnaces, deducting the price of ore, is as follows:

$116 72	$113 50		
90 00	90 00		
$26 72	$23 50	$4,592 70	$4,592 70
150	150	4,008 00	3,525 00
1,336 00	1,175 00	$584 70	$1,067 70
2,672	2,350		
$4,008 00	$3,525 00		

By this estimate each furnace receives an annual profit of from $584 70 to $1,067 70, and this by 150 full days' work, with no allowance for the loss incurred by the remaining idle days; and each miner receives annually $238 45.

As these are deductions from estimates given in a very glowing account of the lead business, the result is not likely to be too unfavorable of it taken as a whole; and the conclusion must follow that the chances are against any one furnace doing a good

business, if conducted under the same circumstances that the average of them now are.

It is evident, however, that the manner in which the business is conducted is far from being perfect—that great savings may be effected by means of sufficient capital to be drawn upon when required; the miners being encouraged by it to keep up the supply of ore, and the furnace thus enabled to keep in blast, while also the power is afforded of buying up quantities of ore when it is at a low price. So lead itself may be advantageously bought sometimes of other smelters, or an advance made upon it in anticipation of its sale in the eastern market.

The possession of timber lands also would be no small saving in a district where wood is worth $5 per cord, as it is in the winter at Mineral Point, and where charcoal sells for the exorbitant price of twelve and a half cents per bushel.

The item of hauling may perhaps be somewhat diminished, but this is doubtful. The present method almost universally adopted is, to employ men who come with their own teams from Illinois and take loads from the furnaces to Galena, or, as is sometimes done, to Milwaukie. From Mineral Point to Galena, the common price is twenty cents per hundred pounds, distance forty miles. They use oxen and do not stop at taverns. The oxen for about six months in the year, pick up grass enough on the prairies where they stop in the day or to camp at night. If a man used his own teams and hired drivers, they would require, besides their wages, board at taverns. Though I believed at the time I first considered the subject, that by purchasing mules in Missouri, where they can be bought for from $25 to $40 each, and keeping one's own teams, the cost of transportation might be much lessened, I now think that unless the business would certainly keep them constantly employed, it would not be worth while to try the experiment, particularly should oats cost 37½ cts. per bushel, as they did in the summer of 1841, even after the harvest. Each working mule requires about twelve quarts a day, oxen none. Most of the smelters own several teams of horses, which are generally used for hauling ore. Mules no doubt might be advantageously substituted for them.

The freight from Galena to St. Louis varies in price according to the stage of the water. The charges are from 15 cts. to 30 cts. per 100 lbs. This difference may often make it an object to

delay the immediate sale or shipment of lead for a rise in the river, when one has capital to go on with in the mean time. From Galena to New York $1 25 is considered a fair estimate for the expenses of transportation per 100 lbs.; but it is said this amount may be diminished one third, besides the saving in time, if one goes on himself with a large amount.

Attention begins to be directed to the probability of the ports on the lakes becoming the shipping points for the Wisconsin lead. In this case those mines farthest east would be the most important; these are on Sugar Creek, and a reverberatory furnace has lately been put in operation there. No great confidence, however, is expressed by the miners generally in the continuance of the ores; I did not see them. They lie about one hundred miles west of Racine, the nearest port on Lake Michigan, to which runs the national road, finished to Rock river, on the direct way to the mines at Sugar Creek. This is one of the best roads in the territory; all the gullies are bridged over, and, excepting a few months in the wet season, is very passable. I have made the following estimate, from which some idea may be obtained of the expense of hauling lead across the country.

Estimated expenses of hauling lead one hundred miles east to Racine.

Four horses (or mules better) will haul two tons and come back in eight days, will eat a bushel of oats to a span of horses, or half a bushel to a span of mules, per day. Oats worth, at the most, in the eastern part of the territory 25 cts.

Whole amount of oats for four horses,			$4 00
Hay (if horses are put up at night) 32 nights, 12½,			4 00
Driver 50 cts. per day,			4 00
Board of driver, 75 cts. per day at most,			6 00
Wagon costs $75, horses $75 each, (mules $35,) eight days' interest at 10 per cent.,			1 00
Allow for wear and tear of wagon per year,	$25		
Shoeing four horses per year,	60		
Risk of horses per year,	40	For 8 days,	2 75
	$125		
			$21 75

Now between the lake and Rock river country, no little amount of transportation is constantly going on, and the *back* loads there-

fore would pay for a great part of the whole expense. The price for hauling store goods and pine lumber to Janesville, on Rock river, is 50 cents per cwt., equal to $20 per load of two tons. When it is remembered that all the pine used in the southern part of Wisconsin and northern part of Illinois in the neighborhood of Rock river, must be brought in from the lake, and that this is the best route; and when also the rapid increase of that most favored district, the Rock river country, is remembered, confidence may be felt that a line of teams would be almost supported by the back loads; and to secure one always, it might be an object to the owners to have a depot for lumber at Janesville. Pine boards are worth at Racine from $10 to $15 per thousand feet, or when carried to Rock river they sell for $25. For about two months in the spring and fall seasons, no hauling could be done for bad roads, and perhaps for two months more in the year thirty cwt. would make a load.

By inquiries made of those navigating the lakes, masters of steamboats and schooners, it is found that in common times, when the supply of wheat to be carried east is not in excess, they would contract to take lead to Buffalo and forward it by the canal to New York for $12 per ton—nearly 54 cts. per hundred pounds. That from Mineral Point to New York, was to Galena 20 cts., to New York $1 25=$1 45 per hundred pounds. This leaves 91 cts. per hundred pounds, or $20 38 per ton for the expenses to the lake, to make the amount of transportation equal to that by the way of New Orleans; but the estimated expense was $21 75. The difference and a large balance for any under estimate of the expense from the lake to New York, would be supplied by the back loads.

This subject is entitled to the more serious consideration, from the fact that the lead now used throughout the whole country bordering on the great lakes as well as in New York state, is carried from the mines near the Mississippi river to New Orleans, thence to New York, and by the canal to the lakes, thus making a circuit of nearly the whole Union. To supply shot alone immediately to this vast region, thus saving the expense it runs up for transportation, would seem to be a good business. Loads of it are occasionally now taken from the tower at Helena, on the Wisconsin river, across the country to Milwaukie, but more finds its way back to the territory, even after making the long tour to the south and east.

The great saving in time, too, would be an additional advantage of this route. It is open so early in the spring, that lead would get to New York as soon as from Galena, although it would be on its way first from the latter port.

A charter has been obtained for a canal to be constructed from Milwaukie to Rock river, by which a means of cheap transportation thus far would be afforded; but this is not likely to be soon completed. When it is, the Peccatolica will, no doubt, be cleared and opened for slack-water navigation, and boats will go from the vicinity of Mineral Point down that stream, and either up Rock river, and across to the lake, or down it to the Mississippi.

To treat of all the resources of this favored region, besides its lead and copper and iron ores, would demand the limits of a volume rather than an article for a scientific journal. Blessed with a delightful climate, rich soil, fine streams, its surface and natural growth admirably adapted for grazing, it promises soon to become the most important part of the great western country. Its inhabitants are industrious and enterprising, and the emigrants that are gradually filling the territory, are principally hard working farmers from the eastern states.

Near St. Louis, within six miles of it to the west and southwest, occur the bituminous coal measures; these are also found opposite the city in Illinois, on Muddy Creek to the south, and at various points up the river, as far as the mouth of Rock River; on leaving St. Louis and proceeding to the south one comes immediately to the great calcareous formation beneath them, that is here so productive in lead ore. Heavy beds of sandstone are interstratified with the limestone, and the formation in places partakes more of the arenaceous than calcareous character. The dip of these rocks varies with local causes, for the most part; they appear to lie horizontally. Ledges of granite and ranges of granite hills often intersect the limestone strata, running in a direction nearly north and south. They seldom seem to have affected the dip of the stratified rocks in contact with them, as is usually the case where they have been projected through them, and this would lead to the supposition that the limestone and sandstone had been deposited subsequently to the time when the granite was in its present position. But from the altered nature of the limestone, and from the fact of metallic veins, copper and

iron, being found at the point of contact, I am led to the opinion that the granite is the more recent rock, and that more veins may with confidence be looked for along and near its line of junction with the limestone.

Not only do sandstone beds alternate with the limestone, but in the vicinity of known lead mines, particularly, the limestone comprises heavy beds of a cavernous, siliceous rock, exceedingly hard, like the French burrstone, and like it sometimes suitable for millstones. There too abound in it mammillary and botryoidal masses of quartz rock coated with crystals, veins of calcareous spar, known by the name of "*tiff*," and lumps and beds of hematite iron ore, all which are now considered in Missouri indicative of the proximity of lead ore veins. These, unlike the copper ore veins noticed, occur at a distance from the granite, which agrees well with the position of lead and copper mines in Cornwall; tin and copper being there found near granite, and lead, antimony, manganese, iron, &c. at a distance from it.

The sandstone does not to my knowledge contain veins of ores; these are every where in the limestone, and in those places where the sandstone is the prevailing rock no mines are wrought. This rock is occasionally useful as a building stone, for furnaces particularly, and it sometimes occurs of a suitable quality for the manufacture of glass, as at a locality four miles east of Caledonia on the Farmington road.

The lead ore occurs in various ways, frequently in horizontal strata in the red clay overlying the rock; in true rock veins, which are subject to all the variations in thickness, in richness, and to all the changes that the better known veins in the primary rocks are; and also in vertical fissures in the limestone, either in loose "chunks" in the clay which fills these fissures, or in regular horizontal layers at intervals across them, or incrusting the walls of the fissures, accompanying them as far as they are followed. When the fissures open out into what appears to have been a large cave, now filled with clay and mineral, the ore incrusts each side of the roof and floor, while within is the clay and sometimes an empty space. These caves are often of large size, large enough to admit wheelbarrows or carts, and the incrustation of a foot or more of galena round their walls affords no small profit to the proprietors and miners.

After working through these large openings they are found to shut nearly up, leaving only a crack with a thread of ore, and this often leads on through unprofitable rock to a rich vein again, and to other chambers. The richest mine now wrought in Missouri—Valleé & Perry's, in the southern part of Jefferson County—is of this character. Shafts have been sunk into the hill one hundred and ten feet, and adits driven into the hillsides.

In general the workings are very superficial, much of the ore being raised from the clay diggings, which seldom extend to the depth of twenty feet. Here the ore is in a horizontal position in the clay, as I remarked, and lies in thin sheets of limited and varying width, seldom exceeding thirty feet, and they are probably always in or connected with one of these fissures so common in the limestone. Throughout the several counties which are occupied with this formation, the miner recognizes a proximity to the fissures by the abundance of the peculiar red clay, of the hematite iron ore, and of the botryoidal and mammillary masses of quartz rock, and the exact position of the fissure itself is often indicated to his experienced eye by a slight sinking of surface, and by an east and west or north and south line of bushes or small plants, which have deep striking roots, and choose a situation, where they can send them deep down into the clay. Still these guides are not always sure, for men used to the business often spend a year or more in "prospecting," that is, in sinking experimental shafts, or following a fissure in hopes of its yielding a rich return of ore, and all without success. But by continuing their work, if their means allow of it, they seldom fail of finally striking a "lead," the sale or working of which repays them for all their labor.

Waldron Mine.—This though now considered of little importance is a place where considerable copper ore has been raised. It lies a little east of the Iron Mountain ridge, five miles east of Caledonia. The diggings are on the side of a low hill, and appear to follow an old fissure extending northwest and southeast, nearly in a direct line, with some branching, over an extent of about fifteen rods in length. No rock is exposed any where in place; the loose pieces are of a compact quartz rock, of a similar character with that of the Iron Mountain ridge. Here it may be meeting the limestone, though none is exposed. The diggings are all superficial, and nothing is now to be seen of the contents

of the fissure, but heaps of the red ferruginous earth that was thrown out. In these are seen pieces of hematite iron ore and nodules of flint, with an occasional piece of green carbonate of copper. But the ore was carefully picked out and carried away when the mine was wrought. The greatest depth reached was about fifteen feet. The ore from what I could learn was principally gossan, with lumps of iron ore and green carbonate of copper intermixed, scattered through it. It was taken about two miles to the furnace on Big River, where is good water power, and there smelted. The land, though poor, is covered with an open growth of good sized oaks.

From these insufficient data no conclusion can be drawn as to the real value of such a mine. Actual experiment, by the sinking of shafts properly directed, alone can determine its importance. The lumps of ore that I was able to obtain were not very promising in their quality, but the existence of the gossan is of itself a favorable indication that more ore will be found on sinking deep for it.

The tract of land connected with the mine consists of about one hundred and eighty acres, and could be purchased for $5,000, and probably much less. But though the indications of ore are sufficient to authorize a thorough examination by those interested there in such operations, they could not of themselves warrant a purchase of the property by any persons not engaged in mining in that section of country.

Iron Mountain.—The "Iron Mountain" and "Pilot Knob," two hills composed principally of *oligist* or peroxide of iron, like the iron mountains of Gellvara in Sweden, lie about sixty miles southwest from the Mississippi River, separated from it by a very hilly country. The one is a low hill of about one hundred and fifty feet elevation above its base, and forms a part of the range of primary hills extending along the east side of Bellevue valley. It being low and its sides gently sloping, there is no rock exposed upon it or near it in place. The loose stones found in greatest abundance on the east, south and west sides, are altogether the heavy iron ore with but an occasional piece of quartz either loose or attached to the ore, and these are in so great quantity as to render it certain that this part of the ridge consists mainly of iron ore in the form of a huge vein in the primary rocks. The top being flat, and the north side not falling away

for a great distance, no pieces of ore nor rock are exposed above the soil, but according to reports they may be traced several miles in a northerly direction. The soil itself consists of fragments of iron ore, and most of it, if mixed with the large lumps, would work well in a blast furnace. The pieces scattered about vary in size; few are so heavy that a man could not lift one of them, and they are so numerous that they could long be depended upon for the supply of many blast furnaces, without the necessity of mining at all. Notwithstanding the sterility of the soil, the hill is covered with a good growth of oak, and these trees are sufficiently abundant throughout this section of country to supply all the necessary fuel for large works during many years. But there is no good water power within less than ten or twelve miles. Limestone suitable for flux may be found almost any where in the valleys, and also hematite iron ore of suitable quality to mix with the heavy ores, or better, to work alone. Notwithstanding the abundance and richness of the Iron Mountain ore, it yielding about seventy per cent. of iron, it seems to me improbable that it will soon become of any great importance, even if a company could have a clear title to it, which none is now likely soon to obtain. For it is a difficult ore to work in a blast furnace—it is likely to be contaminated with titanium or other metals, which would much increase the difficulty of working, as well as injure the iron; and bloomeries, even if a great number could be in operation, could not make iron so cheap as to compete with the coke and anthracite iron of Pennsylvania, and the Ohio River country. The distance from the river, and nature of the country between, are also serious objections. Besides, if it were desirable to engage in this business, there is sufficient hematite iron ore, which though it yield only from thirty to forty per cent. is a more profitable ore to work, and may be found in abundance, as I have reason to believe, near the river and near the bituminous coal mines on the other side of it. It is this ore that makes the celebrated Juniata iron, and when smelted with charcoal always makes the softest and toughest bar iron. It was discovered and wrought some time ago near Caledonia, and the Iron Mountain ore was hauled and mixed with it. The furnace was a small quarter stack, and if properly managed ought to have done a good business; but it is now abandoned, probably on account of injudicious management.

Pilot Knob.—This is a much larger hill than the Iron Mountain. It lies about six miles south of it, and seems to form the termination of that ridge to the south. All around rise high hills enclosing this, but none that appear to be a continuation of the ridge. This attains an elevation of about seven hundred feet above the valleys, and is quite steep and rocky. Iron ore more close grained and compact than that of the Iron Mountain, is found in loose pieces at the foot of the hill, and these continue to increase in number and size on ascending. Half way up solid ledges of iron ore and piles of ferruginous rock, resembling blocks of granite on a steep primary mountain, appear. Some of it is a ferruginous and siliceous conglomerate, black or red, and continually varying in its proportion of oxide of iron, from quartz rock to the hardest and most compact iron ore. Some of it is of a slaty structure, easily splitting like slate. At the top it is more massive, and the best ore. Here rises a rocky peak, looking like a rough granite crag, of about sixty feet perpendicular elevation, forming the summit or knob from which the hill takes its name. The surface of the rock is of a gray color, covered with moss, and it would not be distinguished by an indifferent observer from other primary rocks. Huge blocks lie below the perpendicular peak, and the solid ledge itself is exposed along the summit for nearly two hundred feet in length, and forty or fifty in breadth. Nearly all this is found to be the rich peroxide of iron, but a part of it is the ferruginous conglomerate into which it passes, and which perhaps in many other places would be considered workable iron ore. The sides of the hills are covered, when not too rocky, with a good growth of oak, and the valleys and hills around contain valuable forests of these trees, but there is no good water power near, and the country is very thinly settled, the soil being of indifferent quality, and the surface very rough.

Other veins of iron ore are said to occur in the hills around, but none of them are likely soon to become of any practical importance.

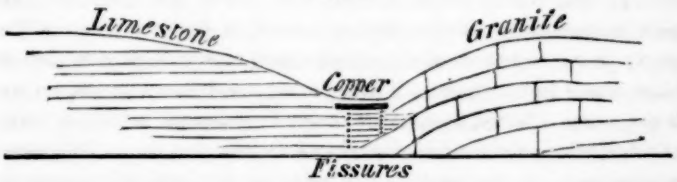
Some indications of *lead ore* are also found near the Iron Mountain range of hills, in Bellevue valley. One shaft, sunk by a Mr. Thomas, in a vertical east and west fissure, to the depth of forty four feet, afforded some galena, sulphurets of iron and copper, and carbonate of lead, sufficient only for specimens, but enough to encourage the proprietor to continue "prospecting" in hopes

to reach a vein that will make a show, and attract a purchaser. The fissure is in limestone, its greatest width about four feet, and has been traced east and west about fifty yards.

Mine La Motte.—This tract of country is about twenty miles east of the Iron Mountain, and is celebrated as containing some of the oldest and most profitable mines in Missouri. It consists of 24,010 acres of land, over different parts of which lead ore has been raised for more than one hundred years. The rock formation over the most of it is the sandstone and limestone, in horizontal strata. Through these, a rock resembling granite has forced its way, and forms ridges and ledges, which make up the remainder of the tract. It is a hard compact rock, composed of quartz and feldspar without mica, and usually of a red color. At its point of contact with the limestone are frequently found horizontal seams of ore, both copper and lead, and these are also found in many places where no rock at all is exposed for several feet down.

The following section shows the position of one of these copper ore veins as far as it has yet been followed.

Fig. 4.



The locality is called the Philadelphia mines. The ore is a carbonate, mixed with what I then took for black oxide of copper, and a considerable proportion of ochre. Until the specimens arrive, and I have an opportunity of carefully examining them, I cannot speak positively of their richness. What I mistook for black oxide of copper in a specimen I preserved from another locality in this tract, I have since found to be an oxide of cobalt and manganese, as will be seen farther on. And I now believe the black earthy mineral that forms a considerable part of the mass of some of the copper ores at the Philadelphia mine, to be the same oxide of cobalt and manganese. The ore is found in a bed consisting of clay with layers of slate and ore irregularly mixed. It is under a stratum of limestone which is very near

the granite beneath. The bed containing the ore is about two and a half feet average thickness; it varies much, however, both in thickness and in the relative quantity of ore, slate and clay. It has been traced along the line of contact of the granite and limestone in an east and west direction for about sixty yards, occupying about twenty yards in width, and always near the surface; the granite is on the south side, the limestone on the north. On the limestone side it has been followed some distance under the rock, and fissures are here found going vertically down and containing some ore in the loose clay that fills them, but their contents are not yet well developed. Attention is paid only to stripping the surface ores. Of these a large quantity was lying in piles near the diggings and at the wash places; estimated amount in rough ore and "sludge," (ore that has been broken and washed ready for the furnace,) about 200,000 pounds. But as it is only a short time that the ores have been wrought, four tons of copper is all that has been made from the whole mine, one ton of which was from the ore of this place. Carbonate of lead in white crystals accompanies this ore.

Two blast furnaces are built on a little stream near by, to smelt the ore, and connected with them are two of the common blast lead furnaces, the whole forming a stack of four furnaces. The water power is not constant, and for that reason they were not in blast when I saw them. There is no good water power on the whole tract. The furnaces are built of sandstone, which is found of tolerable quality and in abundance for the purpose. Oak wood is abundant, but the smelters pay seven cents a bushel for charcoal. The water wheel, eighteen feet in diameter, turns a fan, which keeps up a blast when the water is high, sufficient for the four furnaces. It is to be hoped that the explorations now going on will throw some further light upon the character, not only of these veins of copper ore, but through them upon all those contained in the limestone of this country.

Another deposit of copper ore, nearer the centre of the tract, is wrought by an English miner named Staley. The ore here lies under a great depth of clay and soil, in the deepest place about twenty four feet. A little scattering ore is found on going down to the thick stratum at the bottom; this the workmen say rests on limestone. It varies in thickness, but does not exceed eighteen inches; having been uncovered over an extent of a few

feet only, no one can judge how large a supply may be here obtained. The ore is considered richer than that from any other part of the mines, but I cannot speak positively of its qualities until I have had opportunity to examine the specimens.

Other places which are wrought for lead, furnish copper ore also, in greater or less quantities. At the "Deep Diggings," a light porous carbonate of copper is abundant, with carbonate of lead in white crystals intimately mixed with it, furnishing beautiful specimens. The gangue is a yellowish ferruginous earth, with layers of a black earthy matter running through it. This I found on examination to consist of oxide of cobalt and manganese, not a workable ore of cobalt, but rather a rare mineral, the cobalt of commerce being derived altogether from arsenical cobalt ores.

All these copper ores were, until within three years, considered worthless and troublesome to the workmen in their search for galena; so it was with the rich and easily smelted carbonate of lead, which was buried up in great quantities, and is now redug from out the old rubbish. The proprietors say that the workmen can afford to sell the copper ores prepared for the furnace for less than twenty dollars per thousand weight, and forty dollars per ton.

Owing to the miserable system in which their mining operations are conducted, no attempts have been made to prove the real importance of these ores, and no estimate can be made of their probable duration. The whole estate is owned by a few "proprietors," who do not work the mines themselves, but receive from any one who chooses to work them, one tenth of the produce. The proprietors may as individuals work also on the same terms. A certain lot is marked out to each miner, (most of whom are common farmers from the adjacent country,) and he goes to work after his own ideas of mining, so as to get out the most available ores with as little expense as possible. He has no desire to discover permanent veins, and no care for the welfare of the whole mine, since his interests cannot continue longer than about six years from this time, when the whole falls back again to the sole possession of the proprietors. Thus two hundred men are employed in skimming off the surface ores; one set throwing their rubbish over unwrought tracts, which another set will remove again another year to get at the ore below. Most of the workings are open to the day, and no search is made for

any other ore than that which runs in horizontal strata through the clay or through the rock near the surface. In one instance, however, the limestone rock itself contains so much galena scattered through it, as to render it an object to be quarried, beaten up, washed and smelted. Notwithstanding this rude way of mining—the same hands taking the lead ore through all the different operations of raising, washing, and smelting—they still find the business so prosperous that two hundred men employ themselves on the tract. In their progress they occasionally meet with vertical fissures filled with clay, and more or less ore scattered through them; one miner, more enterprising than the rest, followed one of these fissures down about seventy feet, and then abandoned it, the water coming in.

Some of the lead ores here have been considered argentiferous, but on examining the most promising, a fine steel-grained crystalline galena, by cupelling, I can find no silver; indeed it is only among the lead ores found in the primary rocks that one is led to look for this metal.

There are now nine blast furnaces on this tract, and will be five more in a few months; besides these there are two cupolas and one air or reverberatory furnace. The blast furnaces are driven by four steam engines and one water wheel. The steam engines are of fifteen horse-power each; these are now owned by different individuals, but in six or seven years from this time will belong to the land. Much of the land is suitable for farming, the soil being good and surface gently rolling, but no inducements have been held out to any persons to cultivate it, and with one exception, all the houses on the tract are of the most miserable kind of log cabins plastered with mud. No wells are dug, and little attention paid by any of the people to supply themselves with the common comforts of life.

A certificate published by an agent of the company in 1837, states that for the four preceding years the annual amount of lead manufactured may be estimated at 1,035,820 pounds, of which one tenth came to the proprietors as rent, and that the number of persons employed may be estimated as one hundred and fifty, each of whom receives therefore 69,005 pounds; and the following remarks of the proprietors accompany the certificate.

"Supposing the lead to be worth five cents the pound, we have the sum of $345 for each hand. When we take into considera-

tion the manner in which the hands work, the amount of labor lost by that manner, and the time which they willingly throw away, we cannot fail to be impressed with the belief that no business promises a greater yield from the employment of labor than is offered at the La Motte mines. We close our remarks, confident that the wealth of these mines is as yet scarce known."

As to lead being worth five cents, it may be remembered that it seldom sells in St. Louis for more than four.

Current River.—Between the region just described and the Current river, the country is rough and uninhabited, except by a few half farmers, half hunters, who live with as little labor as is necessary just to support themselves and families.

The rocks are sandstone and limestone, and a quartzose rock into which the sandstone seems to pass on going south, and veins or beds of which fill a large part of the limestone strata. The high hills which one crosses near the heads of Big Black river, and between it and the Current, consist almost universally of this quartzose rock, with the limestone strata just appearing beneath it in the ravines. The roads over the hills are made up of sharp flinty nodules, and these also form the greater part of the surface of the country, rendering it totally unsuitable for cultivation. Some few pieces of lead ore are occasionally found loose in the ravines and valleys. The ridges are of great height and often very steep, forming between the streams narrow "hog-backs," which widen beyond into broad table lands of eight hundred or one thousand feet elevation above the streams below. There are long valleys, too, extending nearly north and south, of no great width, which on either side give place to ground gently rising into the hills beyond, and which appear from their connexion one with another, from their occasionally winding and again spreading out into broad flats like bays, as though they might have been the bed of a large stream long ago left dry. The growth is principally oak and pitch-pine trees of good size, and abundant. Along the banks of the streams are many buttonwood trees of enormous size; sugar-maple too are plenty there, but they do not grow on the hills. The streams are remarkably clear, their bottoms consisting of rolled fragments of quartz, flint, chalcedony, and jasper, and the water runs very quickly over them.

On the Current and Jack's Fork, (a branch of it,) the banks are generally precipitous, the limestone forming steep bluffs of great height, above which, in the hill-tops, the quartzose rock is often seen cropping out. This limestone is of a light gray color, with a crystalline texture, and lies in nearly horizontal strata. The rock is full of quartz veins, which run generally with the stratification, and should rather therefore be called beds of quartz. They are intimately mixed with the limestone, so that it appears sometimes to pass into quartz rock, the two not being easily distinguished, and sometimes the quartz predominates over the limestone in relative proportion. Little nests and bunches of quartz crystals frequently occur, both in the quartz beds and in the limestone. Excepting these, and the calcareous spar in veins, and pearl spar, no minerals were observed. Stains of a greenish hue, like those of carbonate of copper, may be noticed almost every where, on and through pieces of the limestone. I found no fossil shells in the limestone; in the siliceous rock above, a few imperfect encrinites were met with.

A range of igneous rock—a red compact siliceous rock, close grain, flinty fracture, porphyritic near the limestone, crosses Jack's Fork in a direction west of north, east of south, about five miles above its confluence with the Current. A mile or two above this ridge, the limestone is seen dipping about 10° W. S. W., and a mile below, the dip is about as much E. N. E. The ridge formed by this range of igneous rock is about three hundred feet at the highest elevation above the river; it has been traced, it is said, in a north course ten or twelve miles, and it or similar parallel ridges of red rock extend across the line into Arkansas. It crosses Jack's Fork in town XXIX, range 4. In town XXIX, range 3, farther north in the township, another ridge of red rock is to be seen, which will be more particularly noticed when describing "Valleé's diggings."

At the contact of the first range with the limestone on the south side of Jack's Fork, five miles up it, and a mile back, is a deposit of copper ore in the soil, principally a green carbonate, but the black oxide (?) with a little sulphuret forms a considerable part of the whole. This has been dug over to the extent of about three fourths of an acre since 1839, when it was discovered. The diggings extended to the depth of about ten feet average, the deepest hole being eighteen feet; but concerning this I

could get no satisfactory information, no work being now done there. The mine is in a dilapidated condition, and little insight can be obtained as to the true position of the ore. The limestone and red rock meet each other very confusedly, there being near the surface no regular line of contact. Fissures or openings extend vertically down between the rocks, and these are filled with a mixture of iron ore, copper ore, clay and gossan, while above, the surface is composed of gravel, consisting of pebbles of quartz, chalcedony, and jasper mixed with red and yellowish clay. The work over this small tract, which alone was found to contain the ore, was carried on very badly. Instead of the whole surface being stripped off clean to the rock, little holes and trenches were dug all over it, and where the loose ore was found most abundant, there the most digging was done. Sometimes the copper ore forms nearly the whole material from the surface down even to the depth of seven feet, the greatest thickness yet found to consist almost entirely of ore. It lies in irregular shaped masses, accompanied with hematite iron ore, into which it passes, and these masses vary from pebbles up to the weight of seventy pounds. They are scattered through the clay and gossan, or lie sometimes in contact, and sometimes tending to a horizontal position. The clay and gossan are found to be worth washing for the ore they contain. A little spot about twenty feet square, where the ore was most abundant, is said to have produced as much as all the rest. Little veins of copper ore, principally carbonate, may be seen running through the limestone, where it comes to the surface, the thickest not more than half an inch thick; and on the granite under the other ores is often found a thin plate of oxide of copper, incrusting the rock but not joined to it. The grain of the limestone is here irregular, the seams of stratification obliterated, and it is impossible to determine the amount of disturbance it has experienced. Veins of "tiff" (calc spar) are occasionally found in it, and with them small fragments of oxide of copper interspersed, and crystals of pearl spar and pargasite (?)

A rotten vein, a foot thick, at about the point of contact of the two rocks, consists of a curious altered mixture of them, with particles of carbonate of copper scattered through the mass. This sort of breccia is considered of some importance, as indicating the proximity of ore, for almost exactly similar specimens

were found at two other localities to be described. By following this rotten vein, the true lodes will most likely be discovered, if such exist, as there is reason to believe is the case. The loose ore is now pretty much all worked out, and no vein of any importance taking to the rock has been discovered. No attempts to find one by sinking a shaft through the limestone near the granite have been made, though there can be no doubt that the indications and the suitable ground for metallic veins warrant the undertaking. The soil is wet, and from the broken character of the rocks, the water is likely to be troublesome. The locality, however, is on a hillside at the head of a hollow, and all the surface water may be conducted down it. It faces north; on the west side is the red rock ridge, on the east is the limestone ridge; and the little creek marks about the line of junction of the two rocks. A similar little brook has been noticed in a similar position in the two other localities.

The furnace is about a mile from the diggings, on a little stream called Shawnee's Creek, which comes into Jack's Fork not far above its mouth. There the ore is all hauled, beaten up by hand and washed, the gravel and mud washed three or four times, and the workmen receive for it when clean $27 per thousand, gross weight. Some of them found it so profitable at that, as to purchase the right of digging of other workmen; one even agreed to pay $100 for the right to work only about a rod square. The furnace is about three feet high inside and a foot square. It can run only about a week at a time before the whole inside must be pulled out and built up anew, there being no good stone for lining a furnace in the country.

It is several months since the furnace was in operation, and the workmen could give me little account of it. No flux is used except the old slag, which is beaten up and thrown in. The fine ore has not been smelted, owing to the blast blowing it all out of the furnace. This is accumulating, and several tons are ready for smelting, when a proper furnace shall have been constructed. It is built of quartz rock and lined with the same, and was originally much larger and gradually diminished to its present internal capacity. A common overshot wheel, twelve feet in diameter, moves a large blacksmith's bellows, and this is all the machinery about the furnace. The fuel is pitch pine charcoal, which may be obtained in any quantity from government lands for

the expense of cutting and burning. Oak, elm, buttonwood, hickory, maple, cedar, cherry, &c. are plenty. The oak is principally white oak and post oak; locust and mulberry trees grow wild, and the latter bear good fruit.

As to the nature of the ore, its origin, by a right idea of which some judgment may be formed of its probable continuance, it seems that the crevices or fissures which the workmen describe as occurring in their diggings have served as passage ways through which the ore has been projected from below, either in a melted state or in a state of sublimation, or by more slowly acting electrical causes; and that near the surface on the line of fissures, (which is likely to be nearly the line of contact of the two rocks,) the ore has found favorable circumstances to spread and deposit itself; and further, that these same circumstances may be expected to be renewed at different depths, and the ore there found in lateral injections between the limestone strata, in veins and in the main fissures themselves. Veins of calc spar are of frequent occurrence in these rocks, and one in particular was discovered some years since in the red rock not far from the present copper diggings, of uncommon thickness. These also accompany the better developed copper ore veins in the primary rocks on Lake Superior and in other parts of the world; and Dr. Houghton has remarked of them, that they pass into veins of copper ore, and veins of copper ore may be traced through different changes till they become veins of calc spar.

Copper ore as well as lead ore is obtained to some extent in this formation in England. The deepest mine in that country is the Eaton copper mine in Staffordshire, the shaft being four hundred and seventy two yards deep in the mountain limestone.

One of the other localities to which I have referred, as containing indications of veins of copper ore, is on the other side of Jack's Fork, connected with this same red rock ridge, not two miles from the old diggings. The limestone and the red rock are both well exposed, excepting just at the point of contact; they both manifest the same variety of changes as they approach each other that they do at the old diggings—the same porphyritic appearance of the quartz rock, the same breccia that there filled the rotten vein is here noticed, and small pieces of carbonate of copper have been dug up from a hole only four feet deep. But there seems no probability of here finding a large deposit of surface ore.

The third locality is that known as "Valleé's diggings," M. Nereé Valleé, of St. Louis, having spent some time in working there, and owning a large share of the mine. It is on the north side of the Current river, not quite a mile from it, and about seven miles N. N. E. from the old diggings on Jack's Fork. Here too the ore is found at the junction of the red rock and the limestone, on the edge of a little run which had washed out loose pieces of the ore, thus leading to the discovery. All that can be determined of the quality of the ore here is, that there is a seam about four inches thick running horizontally under limestone strata into the hill; what its extent is no one can tell, nor whether it leads to any rich veins. The ore is of a different quality from that at the old diggings, being more of a sulphuret, and this mixed with the blue carbonate as well as the green. It much resembles the ore from Mineral Point, Wisconsin. The red rock belongs to a different ridge from that at the old diggings, being farther east. In character, however, and in the changes the rock undergoes near the limestone, they are the same. Valleé became tired of the country and the business, and quitted both. He did considerable work here, but too injudiciously to determine any thing concerning the capabilities of the mine.

These repetitions of the ore encourage the prospect of this becoming a copper mining country, and naturally lead the people there to look for other veins of ore, which to some extent they have been successful in finding. I have seen ore said to have been discovered near the Current, not far from the Arkansas line, and also from Fourche à Dumas, a stream in that same part of the country. Many discoveries are also reported to have been made by individuals, who think it prudent to keep them secret, now that the government lands are not subject to entry. These localities and others, no doubt, might be discovered by a party of a few men kept at work exploring. But though this may turn out to be a copper mining country, there are many things now operating greatly to its disadvantage. The lands are not yet in the market; the titles to the mines are founded on old Spanish claims, and on the right of preëmption. These are in contest between two parties as regards the old diggings, and their dispute is not likely to be soon settled. Then, whichever party is successful, the mines will be valued at an exorbitant rate, as though they were already proved to be rich and permanent. Then,

too, their remoteness is a serious objection; they are one hundred and forty miles by road from Cape Girardeau on the Mississippi river. The country between is unsettled and poor, and little communication is had across it. All the supplies of weight and bulk must come up the Current river, so that all kinds of store goods are of high price and not easily obtained.

The hills in the neighborhood can never pay for cultivation. It is only the narrow strips along the sides of the large streams that are fertile; these, however, may be made to support a considerable population. The climate is exceedingly unfavorable to enterprise, six months of the year at least being hot and oppressive, if not unhealthy; if the people become accustomed to it, they also become very indolent in their habits, and a laborer there accomplishes in a day about half as much as in other parts of the United States. Still the price of labor for the most common hands, is up to from $12 to $25 per month and found, and a regular miner receives from $20 to $30. There are few slaves in this section of the country. In regular mining, it is considered preferable to pay so much for the ore raised than to give wages, no confidence ever being reposed in the faithfulness of agents. And this is another serious objection—the liability to encounter difficulties with the hands, they being generally of unsettled habits, and all possessing a most independent spirit, that hardly permits them to work for others at all, and causes them to quit for the slightest cause, particularly when the lands around them shall be subject to entry, and they can for a few dollars purchase a farm of their own. Selling the ore is to them, therefore, the most satisfactory way of proceeding, while the mine itself is left to suffer from bad management and want of thorough explorations. The provisions required by the people are of the cheapest kind—corn and bacon, coffee and sugar, being nearly all they need. Corn may be bought at prices varying from twenty five to fifty cents a bushel, and bacon at about eight cents a pound; the other articles at about double their value in a civilized country. Horses are suffered to take care of themselves; they will fatten in the woods after the 10th of April; an abundance of wild hay might be cut if wanted. But few of the settlers keep a supply of hay, fodder or oats; all, however, are well supplied with corn. Cattle can do very well in the woods, and with little expense could be raised in great numbers; so of

hogs. But the wolves and a sickness peculiar to the sheep here, will prevent their being raised to any extent.

It is a good country for water power, fine springs, ever flowing and never freezing, bursting out on the hillsides, and sometimes affording power enough for any works at their very source. Some of these are described as curiosities, such as are seldom met with elsewhere. Connected with these springs by similar causes, are the phenomena of sinking creeks, natural tunnels through the hills, and vast caves hardly explored as yet, all due to the tendency of the limestone to be worn and hollowed out by the action of water. The river being supplied by these springs, and running quick, never freezes over; but it is only at intervals, except in the spring months, that it is up so that rafts can run. When they do go they are carried down very rapidly, but there are no dangerous rapids; boats are sometimes dashed against the cliffs in the sharp turns of the river, which are frequent. Steamboats have come up within eighty miles of the Forks, (Jack's Fork and the Current,) and it is thought that if there were an object, they might come to the Forks in the spring months and during the winter.

There are about ten mills, principally saw-mills, along the Current and its branches, north of the Arkansaw line. Rafts of pitch pine are sent down every year in great numbers. The boards bring from $15 to $20 per thousand feet, but they may be bought for $10 at the mills. They are put together to the amount of six in thickness, and so run nine miles below the state line, when the rafts are doubled.

The copper that was made was sent down on large flat boats, which were constructed for the purpose, and could carry from twenty to thirty tons each. About seventy five tons altogether were made on the Current and thus shipped for New Orleans.

The statistical account of the expenses of making lead, which I had no means in Missouri, as before mentioned, of obtaining, cannot differ essentially from the account given of the Wisconsin furnaces. There is this difference, however, in the price of the "mineral" or lead ore, that when it is sold by the miners in Wisconsin for from $15 to $16 per thousand pounds, it brings them in Missouri about $18 for the same quantity. Lead is worth about half a cent more a pound in St. Louis than it is at Galena.

ART. V.—*Observations on Photographic processes;* by WILLIAM F. CHANNING.

IN the photographic preparations of silver, the agency of light is confined to a change in the arrangement of the particles, or to a partial decomposition. As in galvanic decomposition, it is assisted by coinciding chemical affinities, and these may be brought to act on the salt of silver either in the preparation before exposure to light, or afterwards to bring out the impression. In the Daguerreotype, mercury seems to act mechanically in making apparent the molecular change wrought in the iodide of silver by the action of light. In the recent photographic processes of Talbot, however, a chemical agent is used subsequently to complete the decomposition which light had begun.

A sensitive preparation of silver is one in which "the elements are so delicately balanced as to be overturned by the slightest cause."* The fulminating compounds of silver are examples of such a composition and may form hereafter preparations very sensitive to light. None of the more simple salts of silver are immediately reduced by light, though it may afterwards be made apparent by chemical means that they have undergone a change of structure or that a subsalt has been formed. Thus chloride of silver is apparently insensible to light, unless, for example, organic matter containing carbon, oxygen and hydrogen be associated with it, when the affinity of the carbon for the oxygen, and of the hydrogen for the chlorine, immediately determines a reduction. Thus carbon reduces the oxide of silver in many of its oxy-salts. Electro-positive bodies therefore, which are associated with the salt of silver, tend directly or indirectly to decompose it by removing the electro-negative principle combined with the silver, while an excess of electro-negative elements, oxygen, chlorine, &c. as in the perchlorate, chlorate and hypochlorate of silver, retards decomposition. Thus compounds such as phosphorus, tannic, gallic, crenic, fulminic acids, which may be called deoxidizing agents, all absorbing oxygen, and also another series acting mechanically, such as mercury, deserve attention, first in making a photographic preparation, and second, in bringing out

* Hunt—Griffin's Scientific Miscellany.

an impression after the action of light. There are singular reactions, however, constantly observed in photographic chemistry, which cannot be comprehended or explained by any general statement.

In a recent process of Hunt,* a paper is first prepared with iodide of silver and then washed with ferrocyanide of potassium and used moist. The ferrocyanide contains carbon, potassium, iron and nitrogen without oxygen. Mixed in powder with substances abounding in oxygen, such as nitrate or chlorate of potash, it explodes by heat or percussion. In this case it is easy to see that if water were present a slight cause would determine its oxygen to the ferrocyanide and its hydrogen to the iodine of the silver. Water in the form of water of crystallization, hygrometric moisture, or artificially applied, often thus performs an important part in these preparations. The cyanide of potassium is equally or more efficacious than the ferrocyanide. Besides the inconvenience of using a moist paper, this is not so sensitive as Talbot's calotype paper,† founded on his important discovery of the properties of gallic acid.

For this the paper is washed successively with nitrate of silver and iodide of potassium; then before using with a mixture of acetic acid, nitrate of silver, and gallic acid, which must be made at the time. After a short exposure in the camera, the paper, still apparently unchanged, is washed again with the above mixture, when the impression begins to grow upon the paper in a very striking and beautiful manner. The objection to this process is its complication. The following is a very simple modification of it, nearly as sensitive, and more so than the original Daguerreotype plates.

A piece of best glazed letter paper is fastened by means of a penknife point and some hard wood pegs to a piece of smooth pine board. It is washed over once quickly and evenly by means of a camel's hair brush, with a solution of sixty grains crystallized nitrate of silver in one ounce of water. Let it dry spontaneously, and as soon as dry wash it for a minute with a brush and solution of ten grains of iodide of potassium in one ounce of water. Then instantly wash it with water by dipping it three

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* Report of the British Association, 1841.

† London and Ed. Phil. Mag., Aug. 1841.

or four times in a suitable vessel and dry it by pressing it gently between blotting paper. It is then ready for the camera. One minute is sufficient for a building on which a February sun is shining, four or five minutes for general views. A rather more sensitive paper is prepared by using a mixed solution of five grains of iodide of potassium and five grains of chloride of sodium in one ounce of water instead of the iodide of potassium. Five grains of bromide of potassium in one ounce of water forms a rather less sensitive preparation. These papers may also be made more sensitive by washing them again, after the iodide of potassium, with nitrate of silver, though it will hardly repay the labor. The series of salts of silver, according to their sensibility, when afterwards brought out by gallic acid, appears to be iodide with chloride, iodide, iodide with bromide, bromide, bromide with chloride, chloride, fluoride nitrate; ferrocyanide, sulphocyanide, cyanide. The series with mercury differs essentially from this.

After exposure these papers are still white, but they need only to be fastened as before to another piece of board, and washed over once quickly and evenly with a saturated solution of crystallized gallic acid (only three or four grains in one ounce of water) or with solution of galls, to bring out in a few moments the hidden impression. A weak impression may be brought out by several washings, letting the paper dry between each. Too long an exposure however in the camera is better than too short an one. When it has come out sufficiently, dip it in water and fix it by washing it with the iodide or other solution used in the preparation. Then wash it in water and dry between blotting paper as before.

In views from which copies are to be taken by superposition over other sensitive paper, it is better perhaps to use the bromide throughout, as it leaves the paper whiter and more permeable to the chemical rays, or to fix the paper prepared with iodide by washing with a bromide solution or hyposulphite of soda. Care must be taken in making a proof not to use the nitrate of silver or galls too profusely, otherwise the paper will be stained through. Papers merely washed with nitrate of silver, used as soon as dry, and brought out afterwards by galls, may answer well for copies.

These papers should not be exposed to light or heat during any part of the process, and there should be no delay between the use of the nitrate of silver and iodide of potassium; for the nitrate

on paper is soon decomposed, so that gallic acid discolors it. The iodized paper will keep a long while, unless there is much excess of nitrate of silver. It is best, however, to use it soon after it is made.

It is important to the sensibility of all these preparations, that the nitrate of silver solution should be neutral, have no excess of acid, the electro-negative ingredient; and also that there should be no excess of iodide of potassium, another electro-negative element, on the paper, but rather the reverse. The brushes used should be made without metal, and no metal should touch the paper during its preparation. All the parts of the operation should be kept distinct to ensure a perfect result.

The analogy in these processes to the Daguerreotype is very interesting, iodide of silver being brought out in both cases after the action of light. Though the Daguerreotype cannot be brought out by gallic acid, yet Balard noticed a year ago* that the vapor of mercury would bring out an impression on prepared paper. It is curious to hold one half of a piece of iodized paper, which has received an impression over mercury heated in a capsule, and wash the other half with gallic acid. The first brings out a faint negative sketch, the last a strong negative picture. By preparing a black carbonaceous paper with iodide of silver, the vapor of mercury brings out a sort of positive picture which may deserve some attention.

The solution of galls seems to furnish much that is wanted in a secondary reducing agent. Still the field is open for inquiry. A solution of common tea, from its tannic acid, brings out an impression imperfectly well. Crenic acid, or a solution of peat, which also abstracts oxygen during its decomposition, seems also to have this property.

There is no science which is now advancing so rapidly as photography. These processes will soon undoubtedly be superseded; they may, however, be of interest and use at the present moment.

Boston, February 28, 1842.

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* Comptes Rendus, February, 1841.

Art. VI.—*On the Principle of Virtual Velocities;* by Prof. Theodore Strong.*

We shall premise the following definitions and principles.

Def. 1. Whatever moves or tends to move any portion of matter, is called force; and the point at which the force is applied is called its point of application.

Def. 2. Our idea of force requires us to consider its action as being in a right line which passes through its point of application; this line is called the line of the force's action; and by the direction of the force we mean the direction of that part of this line (reckoned from the point of application) into which the force moves or tends to move the body to which it is applied.

If we represent any given (or assumed) force by unity, then if any other forces contain the unit of force P, Q, &c. times, these forces will be expressed (by the numbers) P, Q, &c. If a body is acted on by two forces in the same direction, their resultant is expressed by their sum, and acts in the same direction as the forces; but if the forces act in opposite directions, the resultant will equal the difference of the forces, and acts in the direction of the greater force.

Investigation of the principle.—Let a body or a system of bodies (or material points) be affected by the forces P, Q, R, &c. in such a manner as to be in equilibrium. Imagine points regarded as fixed to be taken in the lines in which the forces act, such that the forces shall at the same time each tend to increase or decrease the distance of its point of application from the point taken in the line of its action, (the positions of the points in other respects being arbitrary;) we shall call the fixed point which is taken in the line of action of any force (for simplicity) the centre of that force.

Let p, q, r, &c. denote the distances of the points of application of P, Q, R, &c. from their respective centres; then if we denote the sum of the products Pp, Qq, &c. (which are each evidently

* Prof. Silliman—*Dear Sir:* As some objections have been made to the first part of my paper on Virtual Velocities, (see this Journal, Vol. xlii, p. 66,) I have concluded to re-write the part which has been objected to, and to enter more fully into detail in several respects than in that article, for the purpose of clearness and explanation. Yours, &c. T. Strong.

New Brunswick, Jan. 25, 1842.

positive) by M, we get $Pp+Qq+Rr+\&c.=M$, (1). Since the forces balance each other, it is manifest that their action will not alter any of the distances p, q, r, &c.

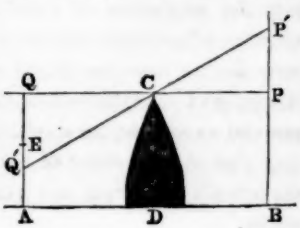
Again, we may evidently conceive the points of application of the forces in their several lines of action to be changed, provided each new point of application is considered as firmly connected with the point to which the corresponding force was at first applied.

Hence if we suppose the points of application of P, Q, &c. to be changed, and denote the new values of p, q, &c. by p', q', &c. (the centres of the several forces remaining unchanged,) and the new value of M by M′, (1) will be changed to $Pp'+Qq'+\&c.=M'$, (2). It is also manifest that there are an indefinite number of ways in which p', q', &c. may be taken (without affecting any one of the forces P, Q, &c.) so that we shall have $M'=M$, or $Pp'+Qq'+\&c.=Pp+Qq+\&c.$ (3). If we use Δ, (the characteristic of finite differences,) when prefixed to any quantity, to denote any finite increment or decrement of the quantity, which is to be considered as positive when the quantity is increased, and negative when it is decreased, we shall have $p'-p=\Delta p$, $q'-q=\Delta q$, and so on; hence (3) is easily changed to $P\Delta p+Q\Delta q+\&c.=0$, (4), which ought to be satisfied independently of any arbitrary quantities which may be introduced by Δp, Δq, &c.; that is, the coefficient of each arbitrary independent quantity thus introduced must be put $=0$; as is evident from the consideration that P, Q, &c. do not affect p, q, &c., p', q', &c.; $\therefore$ they do not affect Δp, Δq, &c.

We shall use δ, (the characteristic of variations,) when prefixed to any quantity to denote any indefinitely small variation of the quantity, the variation being considered as positive when the quantity is increased, and negative when it is decreased. The forces being supposed to be in equilibrium, let the position of the body or system be very slightly changed, (but in a manner consistent with its conditions, or with the connections of its parts in the case of a system;) and that in consequence of the change of position, p, q, &c., P, Q, &c. become $p+\delta p$, $q+\delta q$, &c., $P+\delta P$, $Q+\delta Q$, &c.; also that M becomes $M+\delta M$, then (1) will be changed to $(P+\delta P).(p+\delta p)+(Q+\delta Q).(q+\delta q)+\&c.=M+\delta M$, (4). It is manifest that $p+\delta p$, $q+\delta q$, &c. are equal to their projections on p, q, &c. (in (1),) when quantities of the orders $(\delta p)^2$, $(\delta q)^2$, $(\delta p)^3$, &c. are rejected, also by rejecting quantities of the

same orders of minuteness $P+\delta P$, $Q+\delta Q$, &c. may be supposed to act in p, q, &c.; hence the forces $P+\delta P$, $Q+\delta Q$, &c. in (4) may be supposed to act in p, q, &c., the distances of their points of application from the centres being $p+\delta p$, $q+\delta q$, &c. Again, δP, δQ, &c. may be supposed to act at the same points and in the same lines as P, Q, &c. in (1), $\therefore$ by changing P, Q, &c. into $P+\delta P$, $Q+\delta Q$, &c. without changing p, q, &c., also using $M+\delta M'$ to denote what M becomes, (1) will become $(P+\delta P)p+(Q+\delta Q)q+\&c.=M+\delta M'$, (5). Now the forces P, Q, &c. in (5), which are the same as in (1), balance each other; also the forces δP, δQ, &c. in (5) will balance each other when quantities of the order $\delta P.\delta p$, $\delta Q.\delta q$, &c. are rejected, which ought to be done on account of the supposed minuteness of δP, δQ, &c. Now the forces in (4) and (5) are the same, and act in the same lines and directions (when quantities of the orders $(\delta p)^2$, $(\delta q)^2$, $\delta P.\delta p$, &c. are rejected,) the points of application of $P+\delta P$, $Q+\delta Q$, &c. in (4) being at the distances $p+\delta p$, $q+\delta q$, &c. from their centres, and at the distances p, q, &c. in (5) from the same centres; but the forces in (5) are in equilibrium, $\therefore$ they ought (by what has been shown before) to be in equilibrium in (4), supposing the corresponding points of application of each force in (4) and (5) to be firmly connected; hence we may equate the first members of (4) and (5), and indeed we ought to equate them to indicate that the forces are the same; hence we have $(P+\delta P).(p+\delta p)+(Q+\delta Q).(q+\delta q)+\&c.=(P+\delta P)p+(Q+\delta Q)q+\&c.$, or by reduction $(P+\delta P)\delta p+(Q+\delta Q)\delta q+\&c.=0$; or rejecting quantities of the order $\delta P.\delta p$, $\delta Q.\delta q$, &c. we have $P\delta p+Q\delta q+\&c.=0$, (6), which is the equation of virtual velocities as required. It may be remarked, that in applying (6), we must put the coefficient of any independent variation which may be introduced by the variations δp, δq, &c.$=0$, since δp, δq, &c. are independent of P, Q, &c.

Application.—Let QCP be a straight lever, whose fulcrum is C; P and Q the weight and power, which tend to descend in the parallel lines PB, QA, which are perpendicular to the horizontal plane AB; and suppose that P and Q balance each other, to determine the relation of P and Q, supposing CP and QC to be given?



The forces at P and Q will be expressed by P and Q, then by taking B and A for the centres of P and Q, we shall have $p=PB$, $q=QA$, and we shall get $Pp+Qq=P\times PB+Q\times QA$. Again, let the points of application of P and Q be changed from P and Q to P′ and E, these points being taken in the lines PB, QA, (produced if required,) and such that if we denote P′B by p', and AE by q', we shall have as in (3) $Pp+Qq=Pp'+Qq'$, or $(p'-p)P=(q-q')Q$, or $P\times P'P=Q\times EQ$, (a). Join CP′ and produce it to intersect QA in Q′, then the triangles CPP′, QCQ′ being similar, we get $QQ'=\frac{CQ}{CP}\times PP'$, $\therefore QE=QQ'-Q'E=\frac{CQ}{CP}\times PP'-Q'E$, which substituted in (a) we get $P\times P'P=Q\times\frac{CQ}{CP}\times P'P-Q\times Q'E$, (b). Now since P′P is arbitrary, we must equate its coefficients, $\therefore P=Q\times\frac{CQ}{CP}$, or $P\times CP=Q\times CQ$, which gives the well known law of equilibrium in the lever: in order to satisfy (b), we must also put $Q'E=0$; which shows that to satisfy the conditions in (3), the point E ought to have been taken at Q′, where CP′ produced intersects QA.

In a similar way we can easily find the pressure on the fulcrum C, (which is the resultant of P and Q,) and did room permit, we could easily deduce the well known principle of the parallelogram of forces.

ART. VII.—*A dangerous Property of Wood Ashes exposed, and some of their other Properties examined;* by Dr. JOHN T. PLUMMER, of Richmond, Indiana.

TO THE EDITORS OF THE AMERICAN JOURNAL OF SCIENCE.

I HAVE recently devoted some time to a further examination into the properties of wood ashes, and especially into that property by which heat is conveyed from a small space on their surface deeply into the interior of the largest masses. I consider the subject of sufficient importance to claim the attention of the general as well as the scientific reader; for I cannot forbear thinking, that at least some of the mysterious conflagrations which are repeatedly occurring, are chargeable to this hitherto unsuspected cause.

Judging by the remarks of Prof. Hubbard, accompanying two cases of combustion in wood ashes, reported by him in a late number of this Journal,* it appears to be his opinion that the caloric in question was generated within and near the bottom of the heap, by a spontaneous but unknown process. I conceive that the following experiments render this opinion highly improbable, and they go to sustain the view taken by the present writer, so far as it respects the origin of the caloric, and perhaps measurably as it regards the means by which the heat is diffused throughout the ashes. They show that the heat-retaining power is not peculiar to ashes, but is common to various pulverulent substances; that this residue of combustion contains an appreciable quantity of charcoal in a state of minute division; and, as formerly stated, that it is unsafe to deposit hot ashes upon, perhaps, the largest heaps of cold ashes. I shall marshall these experiments under the head of

Ignitibility of Wood Ashes.—1. A pint of sifted ashes was made into a conical heap four inches high, upon a folded newspaper, and a coal lighted at one corner only, was laid upon the summit and very slightly covered. In seventeen minutes the coal was examined and found to be wholly ignited. It was again covered, and in eleven minutes afterward, that part of the paper on which the ashes rested became quite warm, and also the board beneath it. On sliding the paper nearly off the board, and gently bending it convexly upwards, I succeeded in producing a fissure, extending from the apex of the cone downward to a considerable depth. By this means I was enabled to see the interior of my diminutive volcano, and to discover that the ashes within were *red hot*, if not incandescent, as far down as the fissure extended. After this peep, I closed up the crater by sliding the paper back upon the board, and waited an hour from the beginning of the experiment. At the expiration of this period, the coal was not wholly consumed, and the ashes were still quite warm.

The coal used in the foregoing instance was of sugar-tree wood, and at the time it was placed upon the ashes, two other coals, one of sugar-tree and the other of beech, were thoroughly ignited and

* Vol. xlii, p. 165, *et seq.*

laid upon a board. In two minutes the "fire went out" of both these coals.

2. A wooden pill-box of the largest size was filled with sifted ashes, and an oak coal weighing seven grains was barely buried in them. In thirty five minutes the box was very warm all over; and at this time I surrounded it with cold ashes. In twenty minutes more, the ashes within and immediately around the box were uncomfortably hot.

3. I renewed the second experiment, with the exception of not wholly covering the box. The edge was left exposed, to ascertain whether it would not act as a vent to the accumulating caloric. In half an hour I examined the coal, and found it extinct and the ashes cold. The coal in this case was of beech.

4. This beech coal lighted at one corner, was placed on a cone of sifted ashes, as in the first experiment, and in twenty minutes it was thoroughly ignited. I now pressed a cylinder of pasteboard perpendicularly into the ashes, so as to include the coal and most of the heated ashes. The upper edge of the cylinder was left uncovered. I did not examine the coal for an hour; it was at that time not consumed but dead, and the ashes were entirely cold.

5. I built a cone of a quart of pale ashes, and deposited eight or ten dead coals some distance apart, near the base and remote from the surface; at the apex I buried a live coal as before. In three quarters of an hour, stiff paper or a splinter of wood thrust into the centre of the heap took fire; and on demolishing the pile, I found that the heat had descended to the coals below, and ignited them; indeed they were partially consumed, and the whole interior of the base of the cone was extremely hot.

6. A wooden box ten inches deep and eleven inches square, was filled with unsifted ashes as cold as an exposure of several weeks in winter could make them. A pint of hot ashes was thrown upon the middle of the surface and left uncovered. In eight hours all the central portion of the ashes was hot enough to fire wood thrust into it, and two sides of the box were incalescent. In twenty three hours, the bottom of the box was quite warm, the top of the ashes cool, and the sides of the box were becoming cool. A stick plunged to the bottom of the ashes, was drawn out ignited or burnt at the end, but not even charred above it. In thirty hours the bottom of the box was almost insupport-

ably hot; and the upper half of the ashes retained but little heat. In thirty six hours, the temperature of the ashes being much reduced, I emptied the box, and found the bottom of it on the inside near the middle converted to coal, one of the sides considerably charred, and another browned by the heat. Coals were found in different parts of the ashes, but I believe they were confined to those portions through which the heat did not travel.

The ashes used in the foregoing and the subsequent experiments, were derived from the mixed combustion of hickory, beech, sugar-tree, oak, and a few other kinds of wood; and the sieve employed consisted of twenty four by thirty two interstices to the square inch.

To what cause could I attribute the augmentation of heat and its downward course, which the preceding instances exhibit? The plausible answer was, carbon. There, said the spirit of conjecture, was the fire, burning its way into the ashes, and leaving successive portions of them to cool after it had consumed the combustible matter out of them; travelling downward, like the Goth's descent upon Rome, into regions where its fierceness could be fed. There, too, was the *gray* color of the ashes, produced, said conjecture, by the admixture of fine carbonaceous particles with the pure white cineritious matter. To prove that the proper color of wood ashes is white, there lay the beautiful specimen with gossamer lightness upon the hearth, the residue of the undisturbed combustion of a solitary ember; showing the delicate fibrous structure of the original wood; with open avenues on every side, and a thousand apertures within for the free admission of atmospheric oxygen to every atom of carbon; the carbon thus affianced to oxygen had escaped into the air, leaving its white mansion unshaded by its presence. And how could I better account for the various shades of gray which ashes present, than by supposing them to arise from the various proportions of the black powder intermixed? And then, there were the uniform results of repeated trials by fire, in which something escaped out of the contents of the crucible; and what could this be but carbon? Such was the language of imagination before experiment had fully uttered its voice. To strengthen these conclusions, I applied myself to other evidences; but these, to my disappointment, instead of supporting, kicked against my imaginings.

7. Selecting magnesia as an article possessing physical properties somewhat similar to those of ashes, I erected a cone of this material, and at the summit buried a partially ignited coal. In a few minutes I was surprised to find the whole coal was alive with fire. Shortly afterwards the magnesia beneath the coal became ignited, and the bottom of the heap almost intolerably hot.

8. Guided by the specific gravity and the compressibility of the substances employed, I repeated the experiment with pulverized chalk instead of magnesia. The chalk soon became red hot, beneath the coal; and the base of the heap, heated beyond endurance.

Thus discovering that these alkaline earths possessed the same heat-preserving properties as ashes, and that the same downward, centralizing tendency of caloric was shown in all, I was led to the conclusion that the heat eliminated and diffused in the sifted ashes was the result of the combustion of the single coal buried in them; and considering their low conducting and radiating power, it appeared probable that the amount of heat apparent was not very far from the absolute quantity generated during the combustion. In every instance, while the central parts of the cones were red hot, the exterior of the ashes except at the apex was cold throughout the experiment. The caloric is evolved faster than it is diffused, and of course it accumulates within a small sphere near the coal to an igniting temperature; combustible matter lying at the circumference of this sphere, would ignite and generate another ball of fire, and this produce another, and so on indefinitely, or while the last ignited spheres reached new combustible matter. In this manner I conceive the caloric travelled in the fifth and sixth experiments, and I see no reason why it should not under similar circumstances circulate through a bed of ashes spread over the whole earth.

Satisfying myself in this manner that the presence of pulverulent charcoal was not essential to the phenomenon in question, I submitted other powders to similar trials.

9. Fine sand, scorified wood ashes, anhydrous sulphate of lime, common earth, all thoroughly dried, and the earth and sulphate reduced to subtle powders, were severally made the tenements of a fully ignited coal; but in spite of all the persuasion I could command, the coal refused to be buried alive in such sepulchres as these; almost as soon as it was decently interred, it expired.

During my inquiries into this subject, I was induced to compare the physical and other properties of various powders. Omitting my tables of their specific gravity, porosity, &c. as incomplete, I give the other results below. The substances were dried at a high temperature, and passed through the same sieve; the force used in ascertaining the compressibility was sixty pounds.

The *gravity* was determined by weighing a given measure, without compression or jar.

Water, being	1000
Magnesia, was	164
Ashes, ...	356
Chalk, ...	582
Scorified wood ashes, ...	910
Plaster of Paris, ...	921
Common earth, ...	1035
Sand, ...	1358

Compressibility.

The loose measure, being . . .	100
Ashes were reduced in bulk, to . .	25
Magnesia, ...	50
Chalk, ...	50
Plaster of Paris, ...	69
Common earth, ...	69
Scorified ashes, ...	86
Sand, ...	88

The sand could be shaken into a less space than it could be pressed by the force employed.

Conductibility.—I selected neat paper pill-boxes of uniform size, color, &c. and filled them evenly and without jarring, with the several powders tested. On the centre of the surface, I carefully placed very small squares of tin-foil supporting a particle of phosphorus. Thus prepared, the boxes were at the same instant carefully set upon an equally heated metallic plate, and the time of fusion and of deflagration noted. I give, in the subjoined table, the average results of several trials, in seconds.

Magnesia.	Ashes.	Scorif. ashes.	Chalk.	Sand.	Coal.	Earth.	Gypsum.	Sugar.
42.335	112.267	125.242.	123.293	125.242	77.420	182.300	154.314	218.407

When fused, the phosphorus assumed a hemispherical form, and delicate vivid lines shot like lightning from the margin ap-

parently across the semiglobule, and continued thus to play in the most lively manner from various points in rapid succession until inflammation ensued. This pretty miniature pyrotechny can only be seen in the dark.

*Hygrometric Power of Wood Ashes.**—One hundred grains of dried ashes were lightly spread over an area of sixty square inches, and were exposed with due caution in the shade for twenty four hours, when the noon temperature was 62°, and the air clear and calm. In this time they gained no weight; continued exposure for seventy two hours enabled them to gain .55 of a grain. But when the temperature was near the freezing point at noon, they frequently gained in eight to twenty four hours from .66 to 1.66 of a grain. A fine sponge was converted into a sensitive hygrometer by saturating it with a solution of carbonate of potash, and drying it at 170°. Thus prepared the sponge gained from thirteen to forty four per cent. more than the ashes, and it assisted me in making out the following deductions from eighteen experiments on the hygrometric properties of ashes. 1. They absorb atmospheric vapor more rapidly at a low than at a high temperature. 2. They do not cease to act hygrometrically at a temperature considerably below the freezing point. 3. The range of per centage of increase is from 0 to 1.66. 4. Different parcels of ashes possess different degrees of hygrometric power. This is owing perhaps to the varying quantity of potash present.

Carbonaceous Dust in Ashes.—It became interesting to ascertain how much, if any carbon, in a pulverized state, existed in ashes. For this purpose I employed sundry rather rude methods, now to be mentioned. 1. By pouring a sufficient quantity of sulphuric acid on sifted ashes, to moisten them, much caloric was disengaged, and a white paste formed, in which black particles were very obvious. These particles washed and crushed between the teeth, produced the peculiar sensation of breaking charcoal. On diluting this paste with a large quantity of water, a milky mixture (sulphate of lime) was obtained, in which the black particles rapidly subsided. All the black sediment, however, was not coal. 2. One thousand grains of sifted ashes were

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* Your note appended to a former communication from me, requires that I should say now what I ought to have said while penning that communication, that hygrometric dampness *was* expelled from the ashes in the experiment referred to.

stirred in a large quantity of water, and allowed to subside. In a short time the insoluble parts settled at the bottom, and most of the coal with them, very few particles of it floating on the water. Hence the porosity of the coal must have been sufficiently destroyed to render the fragments specifically heavier than this fluid. 3. The washed ashes used in the foregoing experiments, were examined by a microscope, and particles of coal clearly seen in them. Specimens of well burnt and sifted ashes from the stove, exhibited the same appearance. 4. Several hundred grains of sifted ashes were treated with nitric acid, and after long digestion, the residue was washed, dried, and weighed; the quantity was six per cent. of the original weight of the ashes. Under the microscope this residue was found to consist of particles of coal, a greater proportion of black vitrified grains, and transparent particles which scratched glass, and appeared to have undergone partial fusion. 5. One hundred grains of sifted ashes were in like manner submitted to the action of hydrochloric acid. On diluting the solution with water, a black matter was immediately deposited with gray particles beneath it. The black sediment, washed and dried, assumed a black-brown color, and weighed a fraction over six grains. This powder scintillated in the blaze of a candle like coal-dust; under the action of the blowpipe it became gray, but the principal part remained unconsumed.

Having by these means convinced myself of the presence of coal-dust in ashes, it followed that an ordinary fire did not always consume all the carbon of wood; and to arrive at an approximation to the degree of heat necessary to burn it out of ashes, I tried the next experiments. 6. Sifted ashes were pressed firmly into a crucible, and to expel moisture I subjected them to a temperature of at least 440° for an hour. The temperature was ascertained by the fusion of tin. The ashes were then weighed, and subjected to a red heat for half an hour. On weighing again, there was no appreciable loss. Sulphuric acid and the microscope detected, as before, particles of coal in these *crucibulated* ashes. 7. Most of the ashes of the last experiment were placed loosely in the crucible, and again heated to redness for half an hour. The result was as before—no loss of weight. 8. Intimately mixing thirteen grains of coal-dust with four hundred and sixty seven grains of the crucibulated ashes of the seventh experiment, and pressing them together, they were heated to red-

ness for a considerable time. In this case there could be no doubt of the presence of carbon; yet after cooling, the mixture weighed just four hundred and eighty grains, and consequently had suffered no ponderable loss. 9. I now placed the crucible as it came from the furnace in the eighth experiment in a smith's forge, and heated it to incandescence for several minutes. At this heat the ashes lost nine grains, leaving at least four grains of the adventitious carbon unconsumed. 10. Four hundred and eighty grains of sifted ashes, hot from the stove, were put into the crucible, and exposed to the highest heat of a smith's forge for twenty minutes. On cooling, they weighed only four hundred and thirty one grains, having sustained a loss of forty nine grains! The ashes in the middle of the surface were gray, but all other parts throughout were bluish brown, or blackish and brown. The mass was porous, considerably contracted, and cracked through the centre nearly to the bottom of the crucible; it crumbled under considerable pressure, but retained its form in water, yielding up its soluble parts without falling to pieces. Throughout the slag were scattered grains of a beautiful cerulean hue, insoluble in nitric or sulphuric acid, and exhibiting under the microscope a botryoidal surface. These grains were evidently the product of the intense heat of the forge; and if we can suppose a sufficient quantity of alumine present in the ashes, what forbids them being *Hauyne* of domestic manufacture?

During this last crucibulation, care was taken, as before, to prevent the escape of ashes; the crucible was kept erect and well covered with a steel plate, and every precaution used to avoid error. Add to this vigilance, the fact that the ashes did not occupy more than one third the depth of the crucible, and we can hardly conceive that reverberating currents of air from the bellows, could dissipate any of the ashes. But to determine whether the loss was attributable to such an accident, or to the loose state of the ashes, I tried experiment 11. Seven hundred and twenty nine grains of hot, sifted ashes, were pressed into the crucible, and carefully heated in the forge for fifteen minutes. The loss was seventy grains, or 9.6+ per cent. The ashes were scorified, and presented the *hauynoid* grains and every other appearance and property of the slag of the tenth experiment. If no ashes escaped, how shall we account for the loss of weight? Is there a ponderable element in ashes, which has eluded former analy-

ses? Or did the intense heat of the forge decompose some of the constituents of ashes, drive off the gaseous elements, evaporate water of composition, and volatilize any of the solids? Regarding the known constituents of ashes, I ascertained that in one specimen of the scorified ashes there was a trace of caustic lime; I detected it in no other portion of the slag. Water in which the scorified ashes had digested several days, produced a very faint white cloud, on the addition of oxalate of ammonia. Another portion of the water boiled down, exhibited a lively effervescence on the addition of an acid. The slag from the crucible, though exposed to a damp atmosphere for several days, showed no disposition to deliquesce. The long digested and thoroughly washed scorified ashes, produced abundant effervescence with nitric acid; the resulting nitrate had the peculiar bitterness of that salt of lime, and produced a very copious white precipitate with oxalate of ammonia. I judge, therefore, that but a very small quantity of carbonic acid was driven off from the carbonates of lime and of potash; not more perhaps than would be counterbalanced by the oxidation of the iron contained in ashes. The presence of silica, iron, and a sulphate, were satisfactorily shown; an accident prevented me from testing the presence of a phosphate or a chloride. It therefore remains with me a moot question, what occasioned the loss in the tenth and eleventh experiments?

Since the publication of my former communication on this subject, I have received information of other accidents similar to those reported to this Journal, where large quantities of stored ashes had become extensively heated, and sometimes the wooden repository inflamed. In several instances it was known that hot ashes had been thrown upon the heap, under the impression that there was as much safety in doing so, as in depositing them upon the ground remote from combustible matter. What part the small portion of *pulverulent* coal may perform in the propagation of the fire, I am not prepared to say. That coal in some degree of comminution is necessary to the passage of caloric from one part of the mass to another I am convinced; and that charcoal in some state of division exists in most wood ashes, is easily proved by the use of a coarse sieve, to say nothing of the large coals generally apparent, and especially as they float upon the water of the leach-tub. It may here be asked, if this combustible material is thus distributed through the ashes, why does not

the fire always diffuse itself equally in the heap, instead of pursuing a devious path through it? What contingencies may direct its course, I do not know; but nothing more happens here than happens to a piece of paper inflamed at its edge; it seldom consumes equally, but the combustion proceeds in very uncertain directions.

ART. VIII.—*Caricography;* by Prof. C. DEWEY.

(Appendix, continued from Vol. xxxix, p. 53.)

No. 173. Carex *Meadii*, D.

Tab. Cc. fig. 94.

Spicis distinctis; staminifera unica ovato-oblonga parvi-bracteata cum squama oblonga obtusa margine fusca; pistilliferis binis ovato-cylindraceis superne substaminiferis tristigmaticis pedunculatis sublaxifloris, inferiore longo-pedunculatis basi vaginatis; fructibus obovatis subrotundis obtusis nervosis perbrevi-rostratis et retrocurvis, squamam late-ovatam acutam vel obtusam et brevi-mucronata superantibus.

Culm eight to sixteen inches high, erect, leafy towards the base, glabrous, slightly scabrous above; leaves shorter below, linear-lanceolate, flat, smooth, pale green; staminate spike oblong, large, with an oblong obtuse scale tawny on the margin; pistillate spikes two, sometimes one, oblong, round, rather loose flowered, sometimes staminate at the apex, upper short-pedunculate, lower quite long-pedunculate, and both with leafy bracts sheathing at the base; fruit rather loose, obovate, obtuse, nerved, with a very short beak recurved at apex, and orifice closed; pistillate scale ovate, broad, acute, or short mucronate, reddish on the edge and green on the heel; pale green.

This Carex has a remote resemblance to C. *panicea*, and C. *binervis;* differs in several particulars, as well as from C. *polymorpha*. Found by Dr. S. B. Mead at Augusta, Ill.

No. 174. C. *Sartwellii*, D.

Tab. Cc. fig. 95.

Spica composita; spiculis 12–20 ovatis sessilibus subarctis bracteatis distigmaticis inferne pistilliferis, superioribus sæpe presertim staminiferis et inferioribus præcipue fructiferis, vel omnibus

pistilliferis; fructibus ovatis lanceolatis convexo-concavis subulatis subbidentatis, squama acuta ovata paulo longioribus.

Culm fifteen to twenty eight inches high, erect, leafy towards the base, three-sided, striate, scabrous; leaves flat, linear, striate, shorter than the culm, shorter below, and sheathing; spike two inches long and composed of numerous spikelets, fifteen to twenty each, ovate and sessile, simple pistillate below, sometimes with few staminate flowers, sometimes several of the upper spikelets mostly or entirely staminate, the lower half commonly more abundantly pistillate, sometimes all mostly pistillate; stigmas two; staminate scale lanceolate; scale of the fruit ovate, acute, rather broad, and a little shorter than the fruit; light green, stiff plant.

This Carex is near C. *intermedia*, Gooden.; but it differs from it in not having compound and compressed spikelets, and in having smaller fruit, and pistillate scale much shorter and less broad. From C. *marcida*, Boott, it differs in the lower spikelets, and in fruit, which is much shorter and less lanceolate.

Found by Dr. S. P. Sartwell in Junius, Seneca county, N. Y., after whom it is named, with the "genitive termination," and "in accordance with well established rules of botanical nomenclature."

No. 175. C. *macrocephala*, Willd. Tab. Cc. fig. 96.

Dioica; spica pistillifera composita maxima dense ovato-capitata distigmatica inferne substaminifera; fructibus ovato-lanceolatis maximis compressis nervosis glabris bicuspidatis margine serrulatis, squama ovata longo-cuspidata paulo longioribus.

Culm eight to twelve inches high, angular, large, leafy; leaves sheathing, numerous, flat, linear-lanceolate, longer than the culm, lower leaves short; staminate spike large and thick; dicœcious, and stigmas two; fertile spike single, large, ovate, oblong, and composed of many small spikelets compacted into a dense head, sometimes staminate below; fruit large and long lanceolate; plant yellowish green.

This is a very singular and strongly marked species, supposed to inhabit Siberia by Sprengel in Systema Vegetabilium, Ed. 16; Dr. Boott credits it the Northwest coast, and Mr. Nuttall collected it in his tour across the Rocky Mountains, and through the kindness of Prof. Torrey I have been permitted to examine it.

No. 176. C. *Nuttallii*, D. Tab. Cc. fig. 97.

Spica composita; spiculis 5–8 ovatis sessilibus bracteatis distigmaticis superne staminiferis in capitulum denso-aggregatis; fructibus ovatis brevi-lanceolatis concavo-convexis ore integris, squama ovata lanceolata duplo longioribus.

Culm three to six inches high, erect, smooth, obtusely triangular; leaves flat, lanceolate, longer than the culm, with lower leaves shorter, and all sheathing; spike short, dense, five to eight spikelets closely aggregated, bracteate, and the lower with a leafy bract longer than the culm; fruit ovate, short-lanceolate, smooth; stigmas two; pistillate scale broad ovate, lanceolate, and twice as long as the fruit, membranaceous on the margin; color light green.

Collected by Mr. Nuttall on the Rocky Mountains, and named in honor of that distinguished and indefatigable botanist.

Note. C. *cephalophora*, Muh. Vol. X, p. 268. Var. *maxima*, D.

Spica composita; spicis 8–10 ovatis subaggregatis bracteatis flavescentibus; culmo triquetro striato 2-pedali basin foliato; squama ovata cuspidata.

Culm large, erect, acutely triquetrous, leafy towards the base; spikelets forming a loose spike an inch long, with diverging fruit; two stigmas; fruit ovate, lanceolate, winged, scabrous, two-toothed, and its scale about half as long as the fruit, with a cuspidate point extending to the end of the fruit; light green; woods.

The figure in Schk. has only a remote resemblance to this variety, which is so like some varieties of C. *stipata* in general appearance. The spike of this variety is four times as large as that drawn by Schk., who had it from eight to eighteen inches high. This variety grows in woods from two to four feet in height. I have specimens from four to twenty eight inches high. In the herbarium of Muhlenberg one specimen of the large C. *cephaloidea* is placed with this species. The smaller variety, corresponding to the figure of Schk., I have described in this Journal. This variety, so large and fine, was found by Dr. Sartwell, at Penn Yan, N. Y., and had been confounded, except by him, with C. *stipata*, which, however, always grows on wet grounds.

Figures of the following species accompany this paper:

C. *Meadii*, D. Tab. Cc. fig. 94.
C. *Sartwellii*, D. fig. 95.
C. *macrocephala*, Willd. fig. 96.
C. *Nuttallii*, D. fig. 97.
} See Plate II.

Fig. 94.

C. Meadii. D.

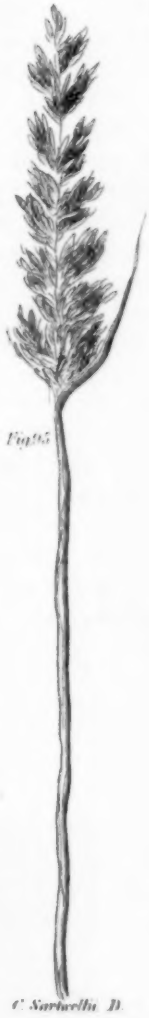

Fig. 95.

C. Sartwellii. D.

Fig. 96.

C. macrocephala. Willd.

Fig. 97.

C. Nuttallii. D.

Dewey's Carices Tab. Cc.

ART. IX.—*On the Dip and Variation of the Magnetic Needle in the United States;* by ELIAS LOOMIS, Professor of Mathematics and Natural Philosophy in Western Reserve College.

[Communicated to the Connecticut Acad. of Arts and Sciences, April 28, 1842.]

I. *Dip of the Magnetic Needle.*

I PROPOSE in the present article to discuss all the observations of magnetic dip in the United States, which have come to my knowledge. Most of these have been given in former numbers of this Journal, and others will be found embodied in the tables which follow. In presenting this enquiry, it is important accurately to determine the annual change of dip. Unfortunately, the materials for this purpose are quite too scanty, and the results very discordant. The earliest observations of the kind I have met with, were made by Prof. Williams, at Cambridge, Mass. 1780–83, and published in the Memoirs of the American Academy, Vol. I, p. 68. According to this authority, the dip in 1783 was 69° 41′. In 1839, I found it to be 74° 20′.1, indicating an increase of five minutes per year. This result might be received as worthy of confidence, were it not that a remark of Prof. Williams throws a suspicion over the accuracy of his observations. He says: "the dip is subject to rather greater diurnal alterations than the variation; but they do not seem to be so regular in their changes. The least dip I have ever observed, was 68° 21′; the greatest, 70° 56′." According to observations at Milan, the diurnal change of dip is somewhat above one minute in summer, and about half a minute in winter. The diurnal change of the variation is, for this latitude, in summer, nearly fifteen minutes. The apparent diurnal motion observed by Prof. Williams must then have been due to the inaccuracy of his observations. The entire range of his observations he reports at 2° 35′. Now I regard it quite certain, that if the above numbers were obtained by observations in all the different positions of the needle as at present practiced, then his instrument was utterly worthless. The probability is that the necessary reversals were entirely neglected, and as no mention is made of reversing the poles of the needle, the presumption is that it was not attended to. In this case, the observations would be charged with a constant error whose

amount we have no means of estimating. In order to obtain more light upon this subject, I addressed a letter to Prof. Farrar, of Cambridge. In his answer he remarks: "I have every reason to believe that the only dipping needle belonging to the apparatus of the college, at the time of Prof. Williams' observations, was one made by Nairne, and is not, I think, to be depended upon. When I have attempted to use it, I have found the needle to rest in positions differing *several degrees* from each other." This last remark corresponds very well with the observations of Prof. Williams. If the original manuscript containing the observations can be found, it is possible that the suspicion which now attaches to them may be removed. At present, however, I place no confidence in them.

The next dip observations in point of age, are those made during Long's expedition to the Rocky Mountains in 1819. The dip at St. Louis, June 16, 1819, is given 70° 30′. I found the dip, Sept. 29, 1841, to be 69° 25′.5, shewing a decrease of about three minutes per year. The dip at Shippingsport is given 70° 15′. Prof. Locke found the dip at Louisville in 1840, 70° 4′, shewing a diminution of half a minute per year. The discordance of these results excites a suspicion of inaccuracy somewhere. A more satisfactory result may be expected by combining all the observations made in 1819, so as to obtain the mean dip at some one station. By this method we may be expected to eliminate in a measure the influence of local attraction, and also accidental errors of observation. The following table presents a summary of these observations, treated in the manner described in a former number of this Journal, Vol. XL, p. 85. As the observations are all comprised within a moderate period, I have not applied any correction to reduce them all to a common instant. Adopting for the central position latitude 39° 3′ N., longitude 91° 37′ W., we obtain the annexed equations of condition.

	Latitude.	Longitude.	Dip, 1819.	Equations of condition.	Diff.	Diff.
Shippingsport,	38° 15′ N.	85° 30′ W.	70° 15′	$1.250=\delta - 48x + 288.2y$	− 13′.8	− 14′.6
Merrimack river,	38 26	89 36	70 0	$1.000=\delta - 37x + 94.8y$	− 0.1	+ 7.9
St. Louis,	38 36	89 36	70 30	$1.500=\delta - 27x + 94.6y$	+24.0	+30.2
Cote sans Dessein,	38 36	91 56	70 50	$1.833=\delta - 27x - 14.9y$	+63.9	
Belle Fontaine,	38 43	89 36	70 0	$1.000=\delta - 20x + 94.4y$	− 10.1	− 5.3
St. Charles,	38 46	89 48	70 5	$1.083=\delta - 17x + 85.0y$	− 5.2	− 0.4
Franklin,	38 57	92 57	69 30	$0.500=\delta - 6x - 62.2y$	− 19.9	− 8.9
Camp,	39 7	94 0	69 45	$0.750=\delta + 4x - 110.9y$	− 2.0	+ 9.9
Charaton,	39 10	92 20	69 50	$0.833=\delta + 7x - 33.3y$	− 12.9	− 5.9
Fort Osage,	39 10	94 18	69 18	$0.300=\delta + 7x - 124.8y$	− 28.3	− 16.1
Cow Island,	39 25	94 0	69 50	$0.833=\delta + 22x - 110.5y$	− 7.7	+ 0.8
Eng. Cantonment,	41 25	95 44	71 7.5	$2.125=\delta + 142x - 185.2y$	+12.3	+ 2.4

These equations solved by the method of minimum squares give $\delta = 1.0801$, $x = +0.00987$, $y = +0.00303$, and the direction of the isoclinal lines is from N. 72° 56′ W. to S. 72° 56′ E. Computing from these data the dip at the several stations, we obtain the differences given in the sixth column above. At Cote sans Dessein, the difference between the observed and computed dip amounts to 63′.9. An error of one degree may perhaps have been committed in recording or transcribing this observation. At all events this observation seems entitled to less weight than the others, and we shall perhaps do best to reject it altogether. The remaining equations solved as before, furnish us $\delta = .97301$, $x = +0.01301$, $y = +0.00397$. Computing again the dip at the several stations, we obtain the differences given in the last column above. The mean dip at St. Louis for 1819 was then, according to these observations, 69° 59′.8. The dip in 1840, according to p. 102, was 69° 20′.7. Decrease 39′.1 in twenty one years, that is, 1′.9 per year. This result would be deserving of confidence if the observations of 1819 could be depended upon. For information on this point, I wrote to Major Graham, who made the observations in question, from whom I learned that the poles of the needle employed were never reversed; and that he knew of no data for determining the correction necessary for this omission. Here then is a constant error of unknown amount, which renders the observations quite useless for our present purpose. This is a result much to be regretted; yet if no observations were made at the time with the polarity of the needle reversed, the loss seems irreparable; for if the instrument were still preserved and in good condition, we obviously could not assume the inequality of the arms of the needle to be the same as in 1819. I do not find then any observations of dip made in this country before 1822, which are capable of informing us whether the dip has been increasing or diminishing.

The next observations in respect of age were made at New York city. Here we have five observations. In order to deduce from them the most probable results, let us put δ for the mean dip, Jan. 1, 1822, and Δ for the annual motion; we thus obtain five equations of condition.

Observations.		Equations of condition.	Differences.	Differences.
1822. Dec.,	73° 0′.5	$\delta + .953\Delta = 60'.5$	$-15'.96$	$+0'.58$
1825. March,	73 27 .0	$\delta + 3.200\Delta = 87\ .0$	$+15\ .02$	
1833. April 1,	72 49 .3	$\delta + 11.246\Delta = 49\ .3$	$-\ 6\ .63$	
1834. Aug. 7,	72 51 .7	$\delta + 12.597\Delta = 51\ .7$	$-\ 1\ .54$	-1.92
1839. Sept. 9,	72 52 .2	$\delta + 17.687\Delta = 52\ .2$	$+\ 9\ .12$	$+1.34$

These equations furnish us $\delta = 78'.365$, $\Delta = -1.9947$, from which data we obtain the differences in the third column above. But three of these observations, viz. the first, fourth, and fifth, were made at the same locality, and are much better suited for comparison. These give $\delta = 60'.434$, $\Delta = -0.5411$, and the differences computed are given in the last column above. I regard this as the most probable value of Δ afforded by the New York observations. In determining the absolute value of the dip, I know no reason for rejecting the other two observations, and assuming the last determined value of Δ, the most probable value of δ is $65'.084$, which gives for Jan. 1, 1840, 72° 55′.34. It will be noticed I have gone upon the supposition that the motion of the needle has been uniform throughout the entire period; yet the last three observations might lead us to infer that since 1833 the dip had been sensibly stationary.

I know of no other observations made in the United States before the year 1833. In the years 1833 and '34, the dip was observed at several places by Prof. Bache and others; and in the year 1839 I observed at the same stations. The observations were made with different instruments, and seldom at exactly the same localities; nevertheless it may be instructive to institute a comparison. The following table exhibits the two series of observations, with the interval elapsed and the change of dip.

Station.	Date.	Dip.	Observer.	Station.	Date.	Dip.	Observer.	Int'rval in yrs.	Change of dip.
		° ′				° ′			′
Albany,	April, 1833	74 51.1	Prof. Henry,	Alb'ny,	Sept. 4, 1839	74 51.3	Prof. Loomis,	5.728	+5.7
"	Aug. 11, 1834	74 40.1	Prof. Bache,						
Springfield,	Aug. 10, 1834	74 10.7	" "	Spring.,	" 14, 1839	74 6.9	" "	5.096	−3.8
Providence,	Aug 8, 1834	74 2.8	" "	Prov.,	" 19, 1839	73 59.6	" "	5.115	−3.2
West Point,	April 15, 1833	73 25.8	Prof. Courtenay	W. Pt.,	" 5, 1839	73 27.4	" "	5.819	−4.1
"	June 7, 1834	73 37.2	" "						
Philadelphia,	July 29, 1834	72 0.2	Prof. Bache,	Philad.,	1838	71 43.9	Prof. Bache,	5.069	−5.4
				"	" 23, 1839	72 7.1	Prof Loomis		
				"	" 13, 1840	71 53.3	Prof. Bache.		

The entire change of dip, divided by the number of years, gives $-0'.4026$ for the annual motion, which result accords very well with the last value of Δ before determined.

The observations made at Hudson are confined to a short period, nevertheless they possess certain important advantages for comparison. They were all made with the same instrument, at identically the same locality, by the same individual, and after the same method. The following table exhibits the materials for comparison. In the equations of condition, δ represents the mean dip for Jan. 1, 1838, and Δ the annual change of dip.

Observations.		Equations of condition.	Differences.
1838. Sept. 8,	72° 48′.2	$\delta + .684\Delta = 8'.2$	+0′.1
1839. April 22,	46.8	$\delta + 1.304\Delta = 6.8$	−1.4
Aug. 17,	48.4	$\delta + 1.624\Delta = 8.4$	+0.2
1840. Jan. 11,	49.5	$\delta + 2.027\Delta = 9.5$	+1.2
Aug. 31,	49.5	$\delta + 2.665\Delta = 9.5$	+1.1
1841. May 10,	47.4	$\delta + 3.353\Delta = 7.4$	−1.2
Nov. 4,	48.7	$\delta + 3.841\Delta = 8.7$	0.0

These equations give us $\delta = 7'.95$, or the mean dip Jan. 1, 1838, equals 72° 47′.95, $\Delta = +0'.18$, from which we obtain the differences between the observed and computed dips as given in the last column above. I consider then +0′.18 to be a near approximation to the annual change of dip at this place.

Through the politeness of Lieut. C. W. Younghusband, I have been furnished with a copy of the dip observations made at Toronto for 1841. The observations are seventy three in number, made generally twice a week, from April 10th to the end of the year. These have furnished me the following equations of condition, in which δ represents the mean dip for Jan. 1, 1841, and Δ the annual motion.

Equations.	Diff.	Equations.	Diff.	Equations.	Diff.
$\delta + .271\Delta =$ 6′.8	+1′.7	$\delta + .405\Delta =$ 3′.0	−2′.9	$\delta + .559\Delta =$ 3′.4	−3′.4
$\delta + .282\Delta =$ 4.2	−1.0	$\delta + .416\Delta =$ 3.6	−2.3	$\delta + .569\Delta =$ 3.3	−3.5
$\delta + .290\Delta =$ 6.1	+0.9	$\delta + .424\Delta =$ 6.2	+0.2	$\delta + .578\Delta =$ 5.6	−1.3
$\delta + .301\Delta =$ 5.3	0	$\delta + .435\Delta =$ 5.2	−0.9	$\delta + .589\Delta =$ 4.0	−2.9
$\delta + .309\Delta =$ 8.4	+3.1	$\delta + .444\Delta =$ 6.2	+0.1	$\delta + .597\Delta =$ 5.4	−1.6
$\delta + .320\Delta =$ 6.2	+0.8	$\delta + .454\Delta =$ 8.3	+2.1	$\delta + .608\Delta =$ 2.5	−4.5
$\delta + .329\Delta =$ 7.1	+1.7	$\delta + .463\Delta =$ 8.4	+2.2	$\delta + .616\Delta =$ 4.7	−2.4
$\delta + .339\Delta =$ 5.6	+0.1	$\delta + .474\Delta =$ 6.5	+0.2	$\delta + .627\Delta =$ 3.3	−3.8
$\delta + .348\Delta =$ 4.9	−0.7	$\delta + .482\Delta =$ 5.0	−1.3	$\delta + .635\Delta =$ 3.0	−4.2
$\delta + .359\Delta =$ 5.3	−0.3	$\delta + .493\Delta =$ 11.9	+5.5	$\delta + .646\Delta =$ 6.3	−1.0
$\delta + .367\Delta =$ 7.3	+1.6	$\delta + .520\Delta =$ 9.2	+2.7	$\delta + .654\Delta =$ 2.4	−4.9
$\delta + .378\Delta =$ 13.3	+7.6	$\delta + .531\Delta =$ 4.8	−1.8	$\delta + .665\Delta =$ 10.6	+3.2
$\delta + .386\Delta =$ 9.7	+3.9	$\delta + .539\Delta =$ 3.6	−3.0	$\delta + .674\Delta =$ 9.2	+1.8
$\delta + .397\Delta =$ 2.5	−3.3	$\delta + .550\Delta =$ 1.6	−4.9	$\delta + .684\Delta =$ 1.5	−6.0

TABLE CONTINUED.

Equations.	Diff.	Equations.	Diff.	Equations.	Diff.
$\delta+.693\Delta=$ 7.1	−0.4	$\delta+.799\Delta=$ 7.1	−1.0	$\delta+.895\Delta=$ 8.6	−0.1
$\delta+.704\Delta=$ 7.9	+0.3	$\delta+.808\Delta=$10.0	+1.8	$\delta+.903\Delta=$ 8.0	−0.7
$\delta+.712\Delta=$11.1	+3.5	$\delta+.819\Delta=$10.7	+2.5	$\delta+.914\Delta=$13.1	+4.3
$\delta+.723\Delta=$ 7.4	−0.3	$\delta+.827\Delta=$10.3	+2.0	$\delta+.923\Delta=$ 9.4	+0.6
$\delta+.731\Delta=$14.1	+6.4	$\delta+.838\Delta=$10.5	+2.2	$\delta+.934\Delta=$ 7.2	−1.7
$\delta+.742\Delta=$10.3	+2.5	$\delta+.846\Delta=$10.8	+2.4	$\delta+.942\Delta=$ 7.1	−1.8
$\delta+.750\Delta=$ 8.5	+0.7	$\delta+.857\Delta=$ 6.6	−1.9	$\delta+.953\Delta=$ 8.2	−0.8
$\delta+.761\Delta=$11.0	+3.1	$\delta+.865\Delta=$ 7.9	−0.6	$\delta+.961\Delta=$10.5	+1.5
$\delta+.769\Delta=$ 9.3	+1.3	$\delta+.876\Delta=$ 3.6	−5.0	$\delta+.972\Delta=$15.5	+6.4
$\delta+.780\Delta=$ 5.9	−2.1	$\delta+.884\Delta=$ 7.4	−1.2		
$\delta+.789\Delta=$ 7.5	−0.6				

The preceding equations give $\delta=3'.57$, or the mean dip Jan. 1, 1841, equals 75° 13′.57, $\Delta=+5'.69$, from which we obtain the differences between the observed and computed dip as given in the table above. Although these observations are quite numerous, and were doubtless made with great care, still being all embraced within a period of less than nine months, they leave considerable uncertainty with regard to the annual motion.

In "Cist's Cincinnati in 1841," Prof. Locke has given the result of monthly observations of the dip at Cincinnati for one year. The mean of the observations for the first six months is 0′.13 greater than for the last, indicating an annual diminution of dip of 0′.26. This result, however, being derived from so short a period, cannot be allowed much weight. These are all the materials to which I have had access for determining the annual change of dip in the United States. I have sought for further light on this subject from a comparison of European observations. The following table shows the annual change of dip in Europe according to Quetelet. These numbers with the motion at New York may be tolerably well represented by the formula $-3'.3605$ sin. (79° 54′+lon.)$=\Delta$, where the longitude is reckoned from Greenwich +E, −W.

Station.	Longitude.	Annual motion.	Comp.	Diff's.	Station.	Longitude.	Annual motion.	Comp.	Diff's.
	° ′	′	′	′		° ′	′	′	′
NewYork,	−74 1	−0.5	−0.34	−0.16	Göttingen,	+ 9 56	−3.05	−3.36	+0.31
Dublin,	− 6 15	2.3	3.22	+0.92	Christiania,	10 44	3 56	3.36	−0.20
London,	0 0	2 4	3.30	+0.90	Florence,	11 16	3 3	3.36	+0.06
Paris,	+ 2 21	3.7	3.33	−0.37	Berlin,	13 24	3.7	3.35	−0.35
Brussels,	+ 4 22	3.4	3.34	−0.06	Upsal,	17 26	3.27	3.33	+0.06
Turin,	+ 7 40	3 5	3.35	−0.15	Stockholm,	18 4	3.13	3.33	+0.20
Milan,	+ 9 9	3 87	3.36	−0.51	Petersburgh,	30 19	3.8	3.15	−0.65

The same formula gives for Hudson $\Delta=+0'.09$. The results of the observations in the United States are by no means satis-

factory, yet I think we shall not be very far from the truth if we assume that the dip in the eastern states decreases 0′.5 per year, and is stationary in the western states. In the subsequent discussion, I have in part evaded the difficulty, by assuming Jan. 1, 1840, as the common epoch, which is not far from the mean time of the observations.

In discussing the observations, I have divided them into four groups according to longitude. The following table contains all the observations between longitudes 71° and 78° W. which I have been able to obtain. Where several observations have been made at the same locality, I have endeavored to deduce the most probable mean result.

TABLE I.—*Observations of the Magnetic Dip from* 71° *to* 78° *west longitude.*

Station.	Lat.	Lon.	Dip.	Date.	Authority.	Dip Jan. 1, 1840.	Diff.
	° ′	° ′	° ′			° ′	′
Montreal,	45 30	73 42	76 42.7	1835. Nov. 25	Capt. Back and Major Estcourt,	76 40.7	−14.8
Oswego,	43 26	76 36	75 11.3	1839. Sept. 1	Prof. Loomis,	75 11.1	+ 4.8
Utica,	43 7	75 13	74 57.2	1839. Sept. 3	" "	74 57.0	+ 3.8
Syracuse,	43 0	76 14	74 50.9	1839. Sept. 2	" "	74 50.7	+ 5.4
Schenectada,	42 48	73 55	74 36.1	1839. Sept. 3	" "	74 35.9	− 4.1
Albany,	42 39	73 45	74 47.5	1835. Nov. 19	Profs. Henry, Bache, and Loomis,	74 45.4	+12.5
Cambridge,	42 22	71 8	74 20.1	1839. Sept. 17	Prof. Loomis,	74 19.9	− 4.0
Dorchester,	42 19	71 4	74 19.0	1839.	Prof. Bond,	74 18.8	− 2.9
Worcester,	42 16	71 48	74 20.6	1839. Sept. 16	Prof. Loomis,	74 20.4	+ 2.7
Springfield,	42 6	72 36	74 8.8	1837. Feb. 26	Profs. Bache and Loomis,	74 7.4	− 0.3
Longmeadow,	42 2	72 36	74 5.3	1839. Sept. 14	Prof. Loomis,	74 5.1	+ 0.7
Providence,	41 49	71 25	74 1.2	1837. Feb. 27	Profs. Bache and Loomis,	73 59.8	+ 3.8
Hartford,	41 46	72 41	73 58.1	1839. Sept. 13	Prof. Loomis,	73 57.9	+ 7.0
West Point,	41 23	74 0	73 30.1	1835. Oct. 19	Profs. Courtenay and Loomis,	73 28.0	− 1.0
New Haven,	41 18	72 58	73 26.7	1839. Sept. 11	Prof. Loomis,	73 26.5	− 0.5
New York,	40 43	74 1	72 55.3	1840. Jan. 1	Messrs. Sabine, Franklin, Back, Bache, and Loomis,	72 55.3	− 0.4
Princeton,	40 22	74 40	72 47.1	1839. Sept. 21	Prof. Loomis,	72 46.9	+10.1
Philadelphia,	39 57	75 11	71 56.1	1838. May 20	Profs. Bache and Loomis,	71 55.3	−19.3
Baltimore,	39 17	76 37	71 35.6	1840. May 16	Messrs. Courtenay, Loomis, Bache, Nicollet, and Graham,	71 35.8	− 2.6
Washington,	38 53	77 1	71 17.5	1839. Feb. 9	Lieut. Wilkes and Prof. Loomis,	71 17.0	− 0.5

The observations are all reduced to Jan. 1, 1840, by applying the annual motion −0′.5. Adopting for the central position latitude 41° 51′ N., longitude 73° 52′ W., we obtain twenty equations of condition of the usual form. From these equations we obtain $\delta = 2.8772$, $x = +.01389$, $y = +.00077$, and the direction of the isoclinal line is from N. 86° 50′ W. to S. 86° 50′ E. The increase of dip in the normal direction is 50′.077 to sixty geographical miles. Computing from these data the dip at the several stations, we obtain the differences given in the last column above. Four of these differences exceed ten minutes. The assumed dip at Montreal is the mean of the two following observations:

77° 6′.4	1833. April 19.	Capt. Back.
76 19	1838.	Major Estcourt.

As the computed dip falls between the two observations, it cannot be pronounced inadmissible.

At Albany, observations made within about a year of each other differ 11′. Here then is evidence of local attraction. The least observed dip reduced to 1840 differs 4′.5 from the computed dip. At Princeton, the dip is derived from a single observation. At Philadelphia, observations made within a year of each other differ 23′.2. Here is undoubted local attraction. My own observation differs 7′.5 from the computed dip.

In order to test the hypotheses upon which the dip is computed, let us classify the differences. The mean difference at the ten most northerly stations is +0′.3; at the ten most southerly −0′.3; at the five most eastern 0′.0; at the five most western +2′.2; at the ten intermediate stations −1′.1. It may be inferred then that within the limits of the preceding table, the hypothesis of straight, parallel, and equidistant isoclinal lines, is well nigh rigorously exact. There is then reason to believe that these differences between the observed and computed dip, arise chiefly from local attraction and errors of observation. As the dip observed at Charlottesville, Va. in 1834, 71° 8′.7, is about half a degree greater than observations made in other parts of the United States would lead us to expect, I have thought best to omit it in this comparison.

TABLE II.—*Observations of the Magnetic Dip from 78° to 83° west longitude.*

Station.	Lat.	Lon.	Dip.	Date.	Authority.	Diff.
Toronto,	43°33′	79°20′	75°13′.6	1841. Jan. 1,	Lt. Younghusband.	− 3′.0
Buffalo,	42 53	78 55	74 40 .8	1839. Aug. 31,	Prof. Loomis.	− 4 .5
Detroit,	42 19	82 56	73 36 .7	1841. April 1,	"	+ 1 .8
Cleveland,	41 30	81 42	73 14 .6	1840. Oct. 1,	"	+10 .9
Sandusky,	41 29	82 40	72 57 .8	1839. May 20,	"	+ 4 .8
Kinsman,	41 28	80 34	73 8 .1	1840. Sept. 10,	"	− 5 .4
Bedford,	41 24	81 32	72 58 .1	1840. Sept. 23,	"	− 1 .9
Hartford,	41 20	80 34	72 59 .8	1840. Sept. 10,	"	− 6 .6
Bazetta,	41 20	80 45	72 59 .7	1840. Sept. 9,	"	− 4 .8
Aurora,	41 20	81 20	72 55 .5	1840. Sept. 8,	"	− 3 .0
Twinsburgh,	41 20	81 26	72 51 .3	1840. Sept. 23,	"	− 6 .2
Warren,	41 16	80 49	73 0 .7	1840. Sept. 11,	"	+ 0 .4
Windham,	41 15	81 3	73 3 .4	1840. Sept. 8,	"	+ 6 .4
Shalersville,	41 15	81 13	72 56 .6	1840. Oct. 15,	"	+ 1 .3
Streetsboro',	41 15	81 20	72 53 .0	1840. Oct. 16,	"	− 1 .1
Hudson,	41 15	81 26	72 48 .3	1840. Jan. 1,	"	− 4 .8
Tallmadge,	41 6	81 26	72 51 .2	1841. March 3,	"	+ 6 .1
Clinton,	40 58	81 40	72 44 .0	1841. Oct. 12,	"	+ 8 .5
Fulton,	40 55	81 38	72 38 .9	1841. Oct. 12,	"	+ 5 .7
Beaver,	40 44	80 24	72 40 .3	1839. Oct. 1,	"	+ 4 .2
Dover,	40 33	81 30	72 19 .2	1841. Oct. 11,	"	+ 4 .2
Pittsburgh,	40 32	80 2	72 38 .9	1839. Sept. 30,	"	+ 9 .6
Frasersburgh,	40 9	82 8	71 48 .7	1841. Oct. 9,	"	+ 1 .7
Hebron,	39 59	82 29	71 10 .1	1841. Oct. 8,	"	−24 .3

Adopting for the central position, lat. 41° 18′ N., lon. 81° 12′ W., we obtain the usual equations, which furnish us $\delta = 1.96851$, $x = +.01483$, $y = +.00378$, and the direction of the isoclinal line is from N. 75° 42′ W. to S. 75° 42′ E. The increase of dip in the normal direction is 55′.081 to sixty geographical miles. Computing from these data the dip at the several stations, we obtain the differences given in the last column above. Two of these differences exceed ten minutes, viz. at Cleveland and Hebron. I have observed the dip near Cleveland four times, on different sides of the city, with the following results:

May 9, 1839,	on the	north	side of the city,	73° 26′.0
Sept. 22, 1840,	"	south	"	12 .0
April 23, 1841,	"	west	"	16 .3
Aug. 12, 1841,	"	east	"	4 .3

The assumed dip is the mean of these four observations, and as the computed dip is almost identical with one of the observations, it cannot be pronounced inadmissible. At Hebron, observations were made at two stations, distant about ten rods from each other, with sensibly the same result. As however at Frasersburgh, distant but about twenty miles, the computed dip agrees well with the observed, we may presume that this disturbance is quite limited in extent.

Classifying the differences in the same manner as with table I, the mean at the twelve northern stations is $-1'.5$; at the twelve southern $+1'.5$; at the six most eastern $-0'.9$; at the six most western $-0'.3$; at the twelve intermediate $+0'.6$.

TABLE III.—*Observations of the Magnetic Dip from 83° to 86° west longitude.*

Station.	Lat.	Lon.	Dip.	Date.	Authority.	Diff.
Gros Cap,	46°32′	84°43′	77° 5′.3	1841. Aug. 26	Prof. Loomis,	-10′.7
Fort Brady,	46 30	84 24	77 29 .7	1841. Aug. 26	" "	+16 .1
Mackinac,	45 51	84 41	76 37 .5	1841. Aug. 21	" "	- 2 .2
South Maniton,	45 5	85 38	75 59 .3	1841. Aug. 31	" "	- 1 .6
Ann Arbor,	42 18	83 37	73 15 .2	1840. June 30	" "	-14 .2
Ypsilanti,	42 14	83 32	73 18 .4	1840. June 30	" "	- 7 .4
Monroe,	41 55	83 20	73 25 .6	1840. June 30	" "	+17 .0
Toledo,	41 41	83 25	73 6 .1	1839. May 17	" "	+ 9 .8
Maumee,	41 34	83 32	72 49 .1	1839. May 18	" "	- 1 .3
Pigna,	40 6	84 10	71 35 .8	1840. Aug. 22	Prof. Locke,	+ 1 .9
Urbanna,	40 3	83 39	71 29 .9	1838. March 30	" "	- 0 .3
Columbus,	39 57	83 3	71 4 .3	1840. Jan. 4	Profs. Locke and Loomis,	-19 .3
Springfield,	39 53	83 42	71 27 .4	1838. March 29	Prof. Locke,	+ 6 .0
Dayton,	39 45	84 5	71 22 .4	1839. June 7	" "	+ 7 .5
Lebanon,	39 26	84 6	71 3 .3	1840. Aug. 24	" "	+ 4 .5
Hamilton,	39 23	84 32	70 59 .6	1840. Aug. 20	" "	+ 3 .0
Mason,	39 22	84 13	70 54 .2	1840. Aug. 25	" "	- 0 .9
Cincinnati,	39 6	84 27	70 27 .8	1841. March 12	Profs. Locke and Loomis,	-13 .6
Williamstown,	38 36	84 30	70 4 .1	1840. Sept. 1	Prof. Locke,	-10 .9
Louisville,	38 18	85 37	70 1 .6	1840. April 22	" "	+ 0 .2
Frankfort,	38 14	84 40	69 54 .7	1840. Sept. 4	" "	- 1 .2
Lexington,	38 6	84 18	69 54 .5	1840. Sept. 2	" "	+ 6 .4
Clay's Ferry,	37 53	84 18	69 48 .0	1840. Sept. 3	" "	+11 .4

Adopting for the central position, latitude 40° 57′ N., longitude 84° 11′ W., we obtain $\delta = 3.31612$, $x = +.014728$, $y = -.000735$, the direction of the isoclinal line is from S. 87° 8′ W. to N. 87° 8′ E., and the increase of dip in the normal direction is 53′.088 for sixty geographical miles. The mean of the differences at the eleven most northern stations is +0′.6, at the twelve most southern −0′.6, at the five most eastern stations −0′.2, at the six most western −2′.1, at the twelve intermediate +1′.1. Eight of these differences exceed ten minutes.

TABLE IV.—*Observations of the Magnetic Dip from 86° to 91° west longitude.*

Station.	Lat.	Lon.	Dip.	Date.	Authority.	Diff.
Prairie du Chien,	43° 3′	90°53′	73°16′.6	1839. Oct. 25	Prof. Locke,	−14′.1
Madison,	43 3	89 11	74 5 .0	1840. Oct. 5	Profs. Locke and Loomis,	+23 .9
Campbell's,	43 1	89 26	73 28 .1	1841. Sept. 9	Prof. Loomis,	− 9 .6
Blue Mounds,	43 0	89 36	73 37 .9	1840. Oct. 3	Profs. Locke and Loomis,	+ 2 .3
Hickok's,	42 58	89 47	73 39 .5	1841. Sept. 9	Prof. Loomis,	+ 6 .8
Mineral Point,	42 51	89 58	73 21 .8	1840. Oct. 6	Profs. Locke and Loomis,	− 3 .0
Platteville,	42 43	90 14	73 17 .4	1841. Sept. 11	Prof. Loomis,	+ 1 .9
Turkey River,	42 42	90 48	73 11 .0	1839. Oct. 23	Prof. Locke,	− 0 .1
Little Mahoqueta,	42 31	90 31	73 8 .0	1839. Oct. 20	" "	+ 5 .7
Dubuque,	42 29	90 23	73 5 .0	1839. Oct. 14	" "	+ 3 .8
Galena,	42 28	90 13	73 3 .0	1841. Sept. 7	Prof. Loomis,	+ 1 .8
Sherwood's,	42 27	90 37	73 7 .0	1839. Oct. 11	Prof. Locke,	+ 9 .2
North bank Mah.,	42 23	90 52	72 51 .0	1839. Oct. 9	" "	− 1 .4
Whitewater,	42 18	90 38	72 55 .1	1839. Oct. 8	" "	+ 6 .0
Mahoqueta,	42 14	90 57	72 43 .6	1839. Oct. 1	" "	+ 0 .3
Farmer's Creek,	42 13	90 23	72 33 .1	1839. Oct. 5	" "	−12 .7
Small Mill,	42 4	91 2	72 21 .4	1839. Sept. 30	" "	−11 .8
Iron Ore,	41 55	90 40	72 50 .0	1839. Sept. 27	" "	+23 .2
Chicago,	41 53	87 44	72 47 .7	1841. Sept. 2	Prof. Loomis,	+ 4 .6
Wapsipinnicon,	41 45	90 23	72 14 .9	1839. Sept. 25	Prof. Locke,	− 4 .0
Lost Grove,	41 39	90 9	72 2 .4	1839. Sept. 23	" "	−12 .3
Davenport,	41 28	90 18	71 55 .0	1839. Sept. 13	" "	− 8 .0
Peru,	41 23	89 5	71 51 .1	1841. Sept. 16	Prof. Loomis,	−14 .9
Pekin,	40 35	89 36	71 13 .2	1841. Sept. 18	" "	− 3 .6
Copperas Creek,	40 30	89 48	71 4 .0	1841. Sept. 18	" "	− 6 .7
Montrose,	40 19	90 14	70 54 .0	1839. Sept. 11	Prof. Locke,	− 3 .4
Marion,	39 44	90 14	70 20 .1	1839. Sept. 9	" "	− 3 .7
Louisiana,	39 23	90 50	69 51 .1	1839. Sept. 8	" "	− 8 .7
Bunker Hill,	39 4	89 53	69 49 .1	1841. Sept. 24	Prof. Loomis,	+ 1 .4
Monticello,	38 57	90 5	69 38 .9	1841. Sept. 25	" "	− 0 .8
Upper Alton,	38 55	90 3	69 45 .7	1841. Sept. 23	" "	+ 7 .6
Alton,	38 54	90 4	69 34 .8	1841. Sept. 22	" "	− 2 .2
Edwardsville,	38 50	89 53	69 57 .7	1841. Sept. 23	" "	+23 .4
Vincennes,	38 43	87 29	69 52 .3	1841. Mar. 26	Profs. Locke and Loomis,	+ 9 .0
St. Louis,	38 37	90 4	69 28 .3	1840. Sept. 17	" " "	+ 7 .6
Paoli,	38 35	86 25	69 35 .5	1840. Sept. 20	Prof. Locke,	− 7 .1
Princeton,	38 23	87 30	69 22 .6	1840. Sept. 16	" "	− 1 .5
New Harmony,	38 11	87 48	69 5 .0	1840. Sept. 11	" "	− 5 .6
Mount Vernon,	37 59	87 47	68 56 .3	1840. Sept. 10	" "	− 3 .0

Adopting for the central position, latitude 41° 2′ N., longitude 89° 47′ W., we obtain $\delta = 3.69143$, $x = +0.015972$, $y = +0.002319$, the direction of the isoclinal line is from N. 81° 44′ W. to S. 81° 44′ E., and the increase of dip in the normal direction is 58′.106 for sixty geographical miles. The mean of the differences at the twenty most northerly stations is +1′.6, at the nineteen most

southerly $-1'.6$, at the ten most easterly $-0'.2$, at the ten most westerly $+0'.8$, at the nineteen intermediate $-0'.3$.

The preceding comparisons furnish us with the following results, where column third shows the dip, column fourth the direction of the isoclinal line, and column fifth the increase of dip in the normal direction for sixty geographical miles at the points whose latitudes and longitudes are shown in the first and second columns.

Latitude.	Longitude.	Dip.	Direction of isoclinal line.	Increase of dip.
41° 51′	73° 52′	73° 52′.63	N. 86° 50′ W.	50′.077
41 18	81 12	72 58.11	N. 75 42 W.	55.081
40 57	84 11	72 18.97	S. 87 8 W.	53.088
41 2	89 47	71 41.49	N. 81 44 W.	58.106

With these data, we may trace with some confidence the isoclinal lines of 72° and 73°. They will pass through the following points.

Line of 73° dip.		Line of 72° dip.		
Latitude.	Longitude.	Latitude.	Longitude.	Direction.
40° 47′.85	73° 52′	39° 35′.85	73° 52′	N. 86° 50′ W.
41 20.12	81 12	40 12.67	81 12	N. 75 42 W.
41 43.43	84 11	40 35.54	84 11	S. 87 8 W.
42 23.92	89 47	41 21.32	89 47	N. 81 44 W.

The isoclinal lines are curved lines passing through the above named points and in the directions here given. In the eastern part of the United States this curvature is very gradual and uniform, but near the longitude of 83° 30′ there is a point of inflexion. The isoclinal lines become concave towards the south. This interruption of the general regularity soon ceases, and in the neighborhood of the Mississippi the isoclinal lines are tolerably well represented by portions of the same circular arcs as near the Atlantic. The position here described differs but slightly from that represented on my chart, Vol. 39, p. 41. Other isoclinal lines may be drawn on each side of these from the same data, but with somewhat greater uncertainty. How now are we to regard the differences contained in the last column of the preceding tables? Do they indicate errors of observation,* errors of the hy-

* I much regret that Prof. Locke should have interpreted a former paper of mine (Vol. xl, p. 85) as a 'special effort to discredit his observations.' Such was far from my intention. I had always regarded Prof. Locke's observations as exceedingly valuable, especially as they were made in a region hitherto wholly unex-

potheses on which they are computed, or errors of a different kind? They cannot be principally errors of observation. At several of the stations where the differences are greatest, such as Philadelphia, Columbus, Cincinnati, and Madison, the dip has been repeatedly observed by different individuals, and nearly uniform results obtained. Do they indicate errors of the hypotheses on which they are computed? These hypotheses are that the isoclinal lines over a limited territory are straight, parallel, and equidistant. Doubtless each of these hypotheses may be erroneous, and if the lines are extended over any very considerable portion of the globe, will be palpably so. But how great are these errors within the limits of my several tables? The observations themselves afford data for estimating the errors. The error arising from curvature and want of parallelism of the isoclinal lines, will appear in the unequal mean differences under the several meridians; and that arising from the lines not being equidistant, will appear in the unequal mean differences under the several parallels. We have already seen that for each of the tables, these errors are much less than the mean of the differences.

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plored. But Prof. Locke claimed for his observations an extraordinary degree of accuracy; an accuracy much greater than I could claim for my own, and greater than I had seen claimed by any former observer. In his own language he expected his results would be received with '*surprise*;' and I thought it not amiss to enquire whether the individual observations gave indications of this extraordinary precision. The result was the development of anomalies of precisely the same kind as had perplexed me in my own observations. These anomalies doubtless in a measure neutralize each other by being alternately positive and negative, and are still further reduced by division, so that the mean results may be valuable in spite of them. I have lately had an opportunity of comparing my own observations with Prof. Locke's, by going upon several of his localities. The following is the result of the observations.

	Prof. Locke.		Prof. Loomis.		
	Dip.	Date.	Dip.	Date.	Diff.
Madison,	74° 3′.5	1839. Nov. 2.	74° 6′.5	1841. Sept. 8.	+3′.0
Blue Mounds,	73 40 .9	1839. Oct. 30.	73 34 .9	1841. Sept. 7.	−6 .0
Mineral Point,	73 20 .6	1839. Nov. 5.	73 23 .0	1841. Sept. 6 & 10.	+2 .4
Vincennes,	69 51 .9	1840. Sept. 18.	69 52 .8	1841. Oct. 1.	+0 .9
St. Louis,	69 31 .1	1839. Sept. 5.	69 25 .5	1841. Sept. 29.	−5 .6
Cincinnati,	70 27 .9	1840. Aug. 26.	70 27 .7	1841. Oct. 5.	−0 .2
Columbus,	71 4 .9	1838. April 3.	71 3 .7	1841. Oct. 8.	−1 .2

At none of the above places were the stations employed identically the same except at Cincinnati, and here I have taken for Prof. Locke's result the mean of a year's monthly observations. My own results are upon an average not quite one minute less than Prof. Locke's. I am satisfied then that the two series of observations may be compared, as if they were all made with one instrument.

The differences obtained, after assigning to each isoclinal line its most probable position, will not be identically the same as given in the last column of the preceding tables. In Table I, where the curvature of the isoclinal lines is most gentle and uniform, the discrepancy is slight; in Table II the discrepancy is not great; in Table III, where the isoclinal lines are somewhat undulating, the discrepancies are greater, particularly near the limits of the table; and in Table IV, the discrepancies are quite appreciable at the extreme stations. But making the necessary allowance for these discrepancies, we have still left unaccounted for large differences, amounting at several stations to over fifteen minutes. How are these to be explained? The observations themselves will suffice to answer this question. In 1834, the dip was observed at Baltimore by Prof. Courtenay 70° 58′.6. The dip, according to my computation, should be 71° 38′.4. Difference −39′.8. In 1839 the dip was observed by myself 71° 50′.3. Difference +11′.9. The dip has since been observed by Prof. Bache, Major Graham, and Mr. Nicollet, who have obtained results ranging between 71° 31′.9 and 71° 47′.2. The mean of all the observations is 71° 35′.6, differing from my computation −2′.8. Extreme range of the observations 51′.7. If we reject the observation of Prof. Courtenay, which differs most from the mean, the accordance will be still better. It is obvious, then, that there prevails about Baltimore some influence which causes the dip to change in moderate distances very abruptly. At Philadelphia, observations made within a year of each other in different parts of the city, vary 23′.2. At New York, observations at eight years' interval differ 37′.7. At Montreal, two observations differ 47′.4. At Cleveland, observations by myself at stations about a mile distant differed 21′.7. At Monroe, observations by myself on opposite sides of the town differed 13′.3. In general we may conclude, that wherever the dip is found to be greatly different from what was to be expected from its latitude and longitude, observations made at stations but moderately distant from each other, often less than a mile, will differ materially. Those influences, then, which occasion *abrupt* deviations from the general law of increase of dip with the latitude are quite limited in extent, unlike the principal part of the force which gives direction to the needle. This fact is specially insisted upon by the magnetic committee of the British Association, of which Sir John

Herschel is chairman. The committee urge the importance of magnetic surveys of the surrounding districts in connection with the observations at central stations. "By this means alone can the amount of *station error* for each element at the central stations be ascertained; by which is meant, all that part of each resolved element of the magnetic force, which, not being participated in by the surrounding district, must be attributed to attractions merely local and accidental. Without such surveys, this error cannot be even approximately fixed." (See this Journal, Vol. XLII, p. 154.)

With regard then to the differences shewn in the last column of my four tables, they are all affected by the errors of observation, which however, are believed to be generally quite small, probably seldom exceeding one or two minutes; they are also affected by the errors of the hypotheses by which they are computed, yet it is believed that at few stations do these errors exceed two minutes. The principal part of these differences consists in the *station errors*.

II. *Variation of the Magnetic Needle.*

Although the magnetic chart contained in Vol. XXXIX, p. 41 of this Journal, is thought to give the variation of the needle with sufficient accuracy for common uses, yet for purposes of science it is desirable to attain the greatest possible precision. I have therefore instituted a careful examination of all the observations contained in my two former articles, with such additional observations as have since come to my knowledge. Of the latter class, the most important are those which are given by Prof. Locke in his Report on the Mineral Lands of the United States, Executive Documents, 1839–40, Vol. VI, No. 239, p. 134.

The first enquiry respects the present annual motion of the needle. The following table exhibits the principal materials for this investigation, all taken, with but two or three exceptions, from my former articles. Column fourth shews the *first* and *last* observations at each station employed in determining the annual motion which is shewn in column eighth, and column sixth shews the number of observations. When but two observations are employed, the annual motion is found by dividing the difference of the observations by the included interval, and this happens at

more than half the stations. When however several observations have been made, the result clearly should not rest solely upon the extreme observations. In such cases I have employed the method exemplified on the fourth page of this article, (p. 96.) In selecting the observations, I have preferred where practicable, to compare those which were made by the same individual. Such observations may be presumed to be affected by a constant error, which will have little influence upon the annual motion. Thus at Burlington, Vt. we have (Vol. 34, page 302) a series of observations by Mr. Johnson, from 1818 to 1834, quite consistent with each other; but in 1837 another observation by Prof. Benedict, decidedly inconsistent with the former. Without stopping to enquire which observations represent most accurately the mean variation at that place, it is obvious that the former are much the best suited to indicate the annual motion. Like considerations have guided my selection at other places.

	Lat.	Lon.	Variation.	Date.	No. obs	Years embraced	Annual motion.	Interval of lines	Products	Motion comput'd
Burlington, Vt.	44°27′	73°10′	+7°30′	1818						
			8 50	1834	6	16	+4′.4	30.8	135.52	+5′.2
Chesterfield, N.H.	42 53	72 20	6 0	1820						
			7 45	1836	17	16	6.4	32.3	206.72	5.1
Deerfield, Mass.	42 34	72 29	5 28	1811						
			7 57	1837	2	26	5.7	33.0	188.10	4.9
Cambridge, Mass.	42 22	71 7	7 30	1810						
			9 18	1840	4	30	3.4	32.3	109.82	5.0
New Haven, Ct.	41 18	72 58	4 35	1819						
			6 10	1840	6	21	4.6	36.7	168.82	4.4
Keeseville, N. Y.	44 28	73 32	7 30	1825						
			8 40	1838	2	13	5.4	30.8	166.32	5.3
Albany, N. Y.	42 39	73 45	5 45	1818						
			6 47	1836	7	18	3.6	35.2	126.72	4.6
New York City,	40 43	74 1	4 40	1824						
			5 40	1837	3	13	3.7	45.5	168.35	3.6
Philadelphia,	39 57	75 11	2 25	1813						
			+3 52	1837	2	24	3.6	51.4	185.04	3.2
Milledgeville, Ga.	33 7	83 20	−5 30	1805						
			4 40	1835	2	30	1.7	69.9	118.83	2.3
Mobile, Ala.	30 40	88 11	8 10	1809						
			7 12	1835	2	26	2.2	110.1	242.22	1.5
Cleveland, O.	41 30	81 46	1 30	1825						
			35	1838	4	13	4.5	36.7	165.15	4.4
St. Clairsville, O.	40 10	80 52	3 10	1820						
			2 31	1838	2	18	2.2	37.1	81.62	4.4
New Madison, O.	39 56	84 37	5 23	1826						
			4 51	1838	2	12	2.7	51.4	138.78	3.2
Spring Bank, O.	39 45	83 47	4 54	1818						
			3 14	1838	2	20	5.0	46.1	230.50	3.5
Springboro, O.	39 31	84 16	5 30	1820						
			4 4	1838	2	18	4.8	51.9	249.12	3.1
Marietta, O.	39 25	81 26	2 36	1810						
			1 29	1838	2	28	2.4	33.2	91.68	4.3
Cincinnati, O.	39 6	84 27	5 15	1825						
			4 46	1840	2	15	2.0	52.9	105.80	3.1
Detroit, Mich.	42 24	82 58	3 13	1822						
			2 0	1840	4	18	4.3	41.1	176.73	4.0
Alton, Ill.	38 52	90 12	8 0	1835						
			7 45	1840	2	5	3.0	69.0	207.00	2.4

The annual motions shewn in this table indicate discrepancies which must be ascribed to local attraction and errors of observation. This is particularly true of the Ohio observations, some of the results being more than double of those at other stations moderately distant. The above results should be combined in such a manner as best to eliminate these errors. Within moderate limits, the motion at each locality may be presumed to be inversely as the distance between the lines of equal variation. This hypothesis is known to be untrue for the earth at large, yet it is worth inquiry whether the error is sensible within the limits of the United States. I have therefore multiplied each annual motion by the distance between the nearest lines of equal variation expressed in geographical miles. Column ninth of the preceding table shows the multipliers, and column tenth the products. These products, according to our hypothesis, should be constant. They are indeed quite variable, yet the extreme fluctuations occur in Ohio, at places where the mean motion of the needle must be supposed nearly the same. There is no decided inequality in the mean of these products for the different parts of the United States. I ascribe these inequalities then mainly to accidental causes and not to the hypothesis assumed. They probably arise in part from the employment of different years in determining the annual motion. The mean of all the products is 163.14, which divided by the distance between the lines of equal variation should give the annual motion. Column eleventh of the table shows the result of this computation. These numbers are alternately above and below those in column eighth; and in my opinion represent tolerably well the annual motion in this country. We may now proceed to discuss the absolute variation. In order to obviate as far as possible any objection arising from the uncertainty of the annual motion, I have confined myself to recent observations. Of the one hundred and ninety three observations employed, none were made before 1825, but ten before 1832, and one hundred and twenty were made since 1838. The observations are all reduced to January 1, 1840, by applying the annual motion computed in the manner just explained.

TABLE I.—10 *Stations.*

Station.	Latitude.	Longitude.	Variation.	Date	Annual motion.	Variation 1840.	Differences.
	° ′	° ′	° ′		′	° ′	′
Angle of Maine,	48 0 N.	67 37	+19 12	1838	+8.8	+19 30	− 3
Penobscot Forks,	45 30	68 26	14 45	1825	8.1	15 25	+21
Barton,	44 45	72 9	10 51	1837	5.7	11 8	+31
Farmington,	44 42	70 3	11 20	1838	5.2	11 30	−55
Hampden,	44 37	68 46	13 4	1837	6.0	13 22	− 4
Dixfield,	44 30	70 14	12 0	1838	5.2	12 10	+13
Rumford,	44 30	70 27	11 0	1838	5.2	11 10	−35
Waterville,	44 27	69 32	12 8	1835	5.7	12 36	+ 6
Belfast,	44 18	68 54	13 0	1838	5.7	13 11	+21
West Thomaston,	43 56	69 5	12 0	1838	5.7	12 11	+ 4

Adopting for the central position latitude 44° 55′ N., longitude 69° 31′ W., we obtain ten equations of condition which furnish us $\delta = 2°.2317$, i. e. $+13°\ 13'.9$, $x = +.02555$, $y = +.02093$. Computing from these data the variation at the several stations, we obtain the differences given in the last column above. Mean difference at the six northern stations $+0'.5$; at the four southern $-1'.0$; at the three stations having the greatest computed variation $+4'.6$; three least $+3'.0$; four intermediate $-6'.0$.

TABLE II.—24 *Stations.*

Station.	Latitude.	Longitude.	Variation.	Date	Annual motion.	Variation 1840.	Difference.
	° ′	° ′	° ′		′	° ′	′
Montreal,	45 31	73 35	+9 50	1835	+5.7	+10 18	+21
Champlain,	45 0	73 26	9 30	1838	5.7	9 41	+ 7
West Chazy,	44 52	73 25	9 21	1838	5.7	9 32	+ 4
Potsdam,	44 40	75 1	7 25	1835	5.4	7 52	− 5
Keeseville,	44 28	73 32	8 40	1838	5.3	8 51	− 8
Burlington,	44 27	73 10	9 27	1840	5.3	9 27	+11
St. Johnsbury,	44 26	72 6	9 16	1837	5.5	9 32	−36
Dial Mountain,	44 21	73 49	8 20	1838	5.5	8 31	− 7
Near Cedar Point,	44 3	73 33	8 23	1838	5.5	8 34	+ 1
Near West Moriah,	44 1	73 45	7 39	1838	5.5	7 50	−32
Crown Point,	43 55	73 27	8 47	1838	5.5	8 58	+27
Hanover,	43 42	72 14	9 15	1839	5.2	9 20	0
Warrensburgh,	43 26	73 45	7 15	1838	5.5	7 26	−22
Chesterfield,	42 52	72 29	8 14	1840	5.1	8 14	− 6
Troy,	42 44	73 40	6 4	1827	4.7	7 5	− 7
Williamstown,	42 43	73 13	7 45	1837	5.2	8 1	+27
Albany,	42 39	73 45	6 58	1840	4.6	6 58	− 5
Deerfield,	42 32	72 34	7 57	1837	4.9	8 12	+15
Cambridge,	42 22	71 8	9 12	1840	5.0	9 12	+10
Southwick,	42 4	72 46	8 15	1838	5.0	8 25	+64
House Point,	42 3	70 4	9 20	1835	5.0	9 45	+ 5
Hartford,	41 46	72 41	6 3	1829	5.0	6 58	−10
Hebron,	41 39	72 26	6 10	1835	5.0	6 35	−39
Newport,	41 28	71 21	7 0	1831	5.0	7 45	−15

Central position, latitude 43° 24′ N., longitude 72° 57′ W., $\delta = 2°.44896$, i. e. $+8° 26'.9$, $x = +.01585$, $y = +.01943$. Mean of the differences at the twelve northern stations $-1'.4$; twelve southern $+1'.4$; six stations having greatest computed variation $+0'.2$; five least $+0'.6$; thirteen intermediate $-0'.3$.

TABLE III.—17 *Stations.*

Station.	Latitude.	Longitude.	Variation.	Date	Annual motion.	Variation 1840.	Differences.
	° ′	° ′	° ′		′	° ′	′
Ogdensburgh,	44 41	75 31	+6 10	1838	+5.4	+6 21	+ 4
Rossie,	44 22	75 43	6 43	1839	5.4	6 48	+51
Cazenovia,	42 54	75 54	4 0	1837	4.4	4 13	- 45
Auburn,	42 54	76 38	3 43	1833	4.2	4 12	- 10
Geneva,	42 52	77 3	3 49	1833	4.1	4 18	+17
Hamilton,	42 48	75 34	4 30	1837	4.4	4 43	- 28
Homer,	42 38	76 15	5 5	1840	4.1	5 5	+33
Ithaca,	42 26	76 36	2 51	1833	4.1	3 20	- 48
Oxford,	42 24	75 40	4 30	1837	4.4	4 43	- 9
Guilford,	42 22	75 30	4 30	1838	4.1	4 38	- 21
West Point,	41 25	74 0	6 32	1835	4.0	6 52	+69
New Haven,	41 18	72 58	6 13	1840	4.4	6 13	- 18
East Hampton,	40 59	72 16	6 8	1834	4.4	6 34	- 22
New York City,	40 43	74 1	5 34	1840	3.6	5 34	+15
Flatbush,	40 40	73 59	4 57	1840	3.6	4 57	- 22
Philadelphia,	39 57	75 11	3 52	1837	3.2	4 8	+14
West Chester,	39 57	75 39	3 25	1832	3.2	3 51	+20

Central position, latitude 42° 5′ N., longitude 75° 12′ W., $\delta = 2°.0827$, i. e. $+5° 5'.0$, $x = +.00930$, $y = +.01857$. Mean of the differences at the eight most northern stations $-3'.2$; nine southern $+2'.9$; four stations having greatest computed variation $+3'.7$; four least $+0'.7$; nine intermediate $-2'.0$.

TABLE IV.—19 *Stations.*

Station.	Latitude.	Longitude.	Variation.	Date.	Annual motion.	Variation 1840.	Differences.
	° ′	° ′	° ′		′	° ′	′
Mackinac,	45 51	84 41	−2 59	1827	+3.9	−2 8	+16
Huron Coast,	45 27	83 50	1 55	1840	4.0	1 55	- 16
Michigan,	44 31	85 32	4 30	1838	3.9	4 22	- 42
"	44 31	84 56	2 50	1838	3.9	2 42	+21
"	44 31	84 28	2 45	1838	3.9	2 37	- 5
"	44 31	83 50	2 0	1838	4.0	1 52	+ 2
Thunder Bay,	44 26	83 0	0 45	1840	4.0	0 45	+18
Pointe aux Barques,	43 51	82 42	1 38	1835	4.0	1 18	- 24
Michigan,	43 51	83 6	2 6	1835	4.0	1 46	- 27
"	43 45	84 22	2 55	1832	3.9	2 24	+17
Pere Marquette River,	43 44	85 43	4 34	1837	3.9	4 22	- 16
Saginaw River,	43 36	83 50	2 19	1835	4.0	1 59	+10
	43 20	84 22	3 0	1832	3.9	−2 29	+19
Huron shore,	43 5	82 26	6	1835	4.0	+ 14	+63
	43 0	84 22	3 27	1831	3.9	−2 52	+ 2
Grand River,	42 55	86 10	4 30	1837	3.9	4 18	+32
Macomb County,	42 43	82 40	1 33	1839	4.0	1 29	- 20
	42 30	84 22	4 25	1826	3.9	3 30	- 28
Detroit,	42 24	82 58	1 56	1840	4.0	1 56	- 22

Central position, latitude 43° 49′ N., longitude 84° 4′ W., $\delta = 2°.3429$, i. e. $-2° 20'.6$, $x = +.00472$, $y = +.02429$. Mean of the differences at the ten most northern stations $-4'.0$; nine southern $+4'.4$; five eastern $+2'.1$; four western $-1'.1$; ten intermediate $+0'.4$.

TABLE V.—16 *Stations.*

Station.	Latitude.	Longitude.	Variation.	Date.	Annual motion.	Variation 1840.	Differences.
	° ′	° ′	° ′		′	° ′	′
Buffalo,	42 52	79 6	+1 25	1837	4.1	+1 37	+1
Fairview,	42 5	80 25	0 0	1838	4.4	+0 9	-11
Chardon,	41 36	81 16	− 15	1838	4.4	−0 6	+23
Euclid,	41 33	81 35	−1 30	1825	4.4	0 24	+20
Cleveland,	41 31	81 45	19	1840	4.4	0 19	+34
Brookfield,	41 16	80 37	40	1837	4.2	27	-19
Braceville,	41 16	81 1	50	1838	4.2	42	-16
Hudson,	41 15	81 26	52	1840	4.2	52	- 7
Portage,	41 4	81 34	1 15	1838	4.3	1 6	-10
Wooster,	40 48	81 59	2 1	1837	4.4	1 48	-27
Carrolton,	40 36	81 10	30	1838	4.3	21	+28
Dover,	40 32	81 31	1 50	1838	4.3	1 41	-34
Coshocton,	40 18	81 55	1 30	1838	4.3	1 21	+ 9
Batesville,	39 56	81 17	1 22	1838	4.1	1 14	- 3
Marietta,	39 30	81 28	1 33	1838	4.3	-1 24	+ 6
Charlottesville,	38 2	78 30	0 0	1835	3.7	+0 19	+ 6

Central position, latitude 40° 53′ N., longitude 81° 2′ W., $\delta = °.60404$, i. e. $-36'.2$, $x = +.00676$, $y = +.01648$. Mean of the differences at the eight most northern stations $+3'.1$; eight most southern $-3'.1$; three most eastern $-1'.3$; four western $-3'.7$; nine intermediate $+2'.1$.

TABLE VI.—18 *Stations.*

Station.	Latitude.	Longitude.	Variation.	Date.	Annual motion.	Variation 1840.	Differences.
	° ′	° ′	° ′		′	° ′	′
Lower Sandusky,	41 22	83 10	−2 48	1838	+4.3	−2 39	+16
Flat Rock,	41 18	84 13	3 14	1838	3.9	3 6	+31
Kalida,	40 57	84 9	3 0	1838	3.9	2 52	+46
Logansport,	40 45	86 22	5 35	1836	2.7	5 24	-16
Marion,	40 34	83 9	3 17	1838	3.8	3 9	- 6
Zanesville,	39 59	82 1	2 30	1838	4.3	2 21	+ 3
New Madison,	39 54	84 36	4 51	1838	3.2	4 45	-37
Springfield,	39 52	83 45	4 30	1835	3.4	4 13	-39
Springbank,	39 45	83 45	3 14	1838	3.5	3 7	+28
Washington,	39 32	83 23	3 6	1838	3.4	2 59	+24
Springboro,	39 30	84 9	4 4	1838	3.1	3 58	- 4
Wilmington,	39 26	83 42	4 6	1838	3.3	3 59	-22
Athens,	39 23	82 4	3 12	1838	4.3	3 3	-31
Chillicothe,	39 21	82 55	3 15	1835	3.6	2 57	+11
Jackson,	39 13	82 38	3 10	1838	3.6	3 3	- 7
Cincinnati,	39 6	84 27	4 46	1840	3.1	4 46	-36
Gallipolis,	38 54	82 6	2 35	1838	3.7	2 28	+10
South Hanover,	38 44	85 30	4 35	1837	2.5	4 28	+29

Central position, lat. 39° 52′ N., lon. 83° 40′ W., $\delta = -1.5134$, i. e. $-3°\ 30'.8$, $x = +.00290$, $y = +.01441$. Mean of the differences at the eight most northern stations $-0'.2$; ten most southern $+0'.2$; four stations having the least computed variation $-0'.5$; six greatest $-3'.0$; eight intermediate $+2'.5$.

TABLE VII.—16 *Stations.*

Station.	Latitude.	Longitude.	Variation.	Date.	Annual motion.	Variation 1840.	Differences.
Goshen,	33°52′	82°39′	−5° 9′	1837	+2′.8	−5° 1′	− 1′
Lincolnton,	33 46	82 37	5 9	1837	2.8	5 1	0
Applington,	33 32	82 28	5 0	1837	2.7	4 52	+ 6
Augusta,	33 27	82 1	5 4	1837	2.7	4 56	−19
Waynesboro,	33 4	82 9	5 4	1837	2.7	4 56	− 3
Sandersville,	32 57	82 59	5 27	1838	2.6	5 22	+18
Millhaven,	32 56	81 47	5 4	1837	2.7	4 56	−20
Jacksonboro,	32 49	81 42	4 55	1837	2.7	4 47	−12
Birdsville,	32 48	82 13	5 1	1837	2.7	4 53	+10
Charleston,	32 42	80 4	2 54	1837	3.3	2 44	+26
Swainsboro,	32 38	82 31	5 4	1838	2.6	4 59	+24
Springfield,	32 20	81 31	5 5	1837	2.7	4 57	−21
Savannah,	32 5	81 12	5 5 3 31	1838 1839	2.7	4 13	+12
Bryan C. H.	32 1	81 32	5 5	1838	2.6	5 0	−16
Liberty C. H.	31 48	81 37	5 5	1838	2.6	5 0	− 6
Darien,	31 26	81 37	5 5	1838	2.6	5 0	+ 2

Central position, lat. 32° 46′ N., lon. 81° 55′ W., $\delta = -2°.78999$, i. e. $-4°\ 47'.4$, $x = +.006512$, $y = +.017627$. Mean of the differences at the six most northern stations $+0'.1$; ten most southern $-0'.1$; four most eastern $+0'.2$; three most western $+5'.7$; nine intermediate $-2'.0$.

TABLE VIII.—16 *Stations.*

Station.	Latitude.	Longitude.	Variation.	Date.	Annual motion.	Variation 1840.	Differences.
Toccoa Falls,	34°39′	83°30′	−5° 0′	1837	+2′.8	−4°52′	− 9′
Carnesville,	34 24	83 24	5 1	1837	2.8	4 53	−12
Elberton,	34 6	83 0	4 33	1837	2.8	4 25	+10
Athens,	33 59	83 32	4 31	1837	2.6	4 23	+22
Lawrenceville,	33 57	84 11	5 0	1839	2.4	4 58	− 1
Monroe,	33 50	83 52	5 10	1838	2.4	5 5	−13
Madison,	33 34	83 40	4 29	1838	2.4	4 24	+24
Eatonton,	33 20	83 33	4 32	1838	2.4	4 27	+20
Milledgeville,	33 7	83 24	5 51 4 40	1838 1835	2.4	5 7	−22
Columbus,	32 28	85 11	5 30	1839	2.0	5 28	− 8
Lumpkin,	32 9	84 55	5 27	1839	2.0	5 25	− 9
Cuthbert,	31 49	85 2	5 30	1839	1.9	5 28	− 9
Fort Gaines,	31 38	85 19	5 31	1839	1.9	5 29	− 4
Bainbridge,	30 55	84 46	5 30	1839	1.8	5 28	−12
Tallahassee,	30 26	84 27	5 12	1835	1.8	5 3	+ 9
Pensacola,	30 24	87 23	6 0	1835	1.4	5 53	+14

Central position lat. 32° 48′ N., lon. 84° 19′ W., $\delta = -1°.0443$, i. e. $-5° 2'.7$, $x = +.000795$, $y = +.006077$. Mean of the differences at the seven most northern stations, $+3'.0$; nine most southern, $-2'.3$; four stations having the greatest computed variation, $-1'.7$; five least, $-2'.2$; seven intermediate, $+2'.6$.

TABLE IX.—9 *Stations.*

Station.	Latitude.	Longitude.	Variation.	Date.	Annual motion	Variation 1840.	Differences.
	° ′	° ′	° ′			° ′	′
Florence,	34 47	87 54	−6 28	1835	+1′8	−6 19	+34
Tuscaloosa,	33 12	87 43	7 28	1839	1 6	7 26	−32
Louisiana,	32 50	92 22	8 40	1835	1 6	8 32	−15
"	32 25	92 32	8 30	1836	1.6	8 24	− 3
"	31 50	92 32	8 30	1834	1.5	8 21	+ 2
"	31 45	92 22	8 30	1834	1.5	8 21	+ 1
"	31 40	92 32	8 40	1835	1.5	8 32	− 8
Mobile,	30 42	88 16	7 12	1835	1.4	7 5	+ 5
Louisiana,	29 40	94 0	8 41	1840	1.4	8 41	+16

Central position, latitude 32° 6′ N., longitude 91° 8′ W., $\delta = -1°.9581$, i. e. $-7° 57'.5$, $x = +.000911$, $y = +.005797$. Mean of the differences at five northern stations $-2'.8$; four southern $+3'.7$; two eastern $+1'.0$; three western $+1'.7$; four intermediate $-1'.7$.

TABLE X.—10 *Stations.*

Station.	Latitude.	Longitude.	Variation.	Date.	Annual motion.	Variation 1840.	Differences.
	° ′	° ′	° ′			° ′	′
Davenport,	41 28	90 18	−8 13	1840	+2′6	−8 13	− 9
Illinois,	41 10	88 32	7 25	1838	2.5	7 20	+ 2
"	41 0	88 32	6 50	1838	2.5	6 45	+36
"	40 50	88 32	7 43	1833	2.5	7 26	− 5
Jacksonville,	39 43	90 20	8 45	1833	2.5	8 28	−28
Alton,	38 51	90 15	8 0 / 7 45	1835 / 1840	2.3	7 47	+ 8
St. Louis,	38 37	90 17	8 49	1835	2.3	8 37	−41
Missouri,	37 30	90 2	7 30	1827	2.1	7 3	+43
"	36 40	90 2	8 0	1825	2.0	7 30	+14
Nashville,	36 10	86 52	6 58.5	1832	2.0	6 42	−20

Central position, latitude 39° 12′ N., longitude 89° 22′ W., $\delta = -1°.58465$, i. e. $-7° 35'.1$, $x = -.000899$, $y = +.008730$. Mean of the differences at five northern stations $-0'.8$; five southern $+0'.8$; three having greatest computed variation $-9'.6$; three least $+3'.6$; four intermediate $+4'.5$.

TABLE XI.—27 *Stations.*

Station.	Latitude.	Longitude.	Variation.	Date.	Differ'nces.
Prairie du Chien,	43° 3′	90° 53′	−9° 5′	1840	+ 8′
Madison,	43 3	89 11	7 30	"	+38
	43 3	89 42	8 20	"	+ 8
Campbell's,	43 1	89 26	8 48	"	−31
Blue Mounds,	43 0	89 36	8 38	"	−13
Trout Brook,	42 59	90 45	9 0	"	+ 7
Parish's,	42 58	90 10	8 55	"	−10
Mineral Point,	42 51	89 58	8 40	"	− 4
Turkey River,	42 42	90 48	9 0	"	+ 6
Log House,	42 38	90 43	9 0	"	+ 2
Sherald's Mound,	42 35	90 33	8 10	"	+45
Little Mahoqueta,	42 31	90 31	8 30	"	+23
Dubuque,	42 29	90 23	8 22	"	+25
Galena,	42 28	90 13	9 25	"	− 4
Sherwood's,	42 27	90 37	9 0	"	−30
North branch Mahoqueta,	42 23	90 52	9 35	"	−45
Whitewater,	42 18	90 38	9 10	"	−15
Mahoqueta,	42 14	90 57	8 45	"	+22
Farmer's Creek,	42 13	90 23	9 8	"	−24
Cheney's,	42 12	90 21	9 5	"	−23
Mill,	42 10	90 37	9 15	"	−23
Bridge,	42 6	91 2	9 20	"	−12
Small mill,	42 4	91 2	9 7	"	0
Elkford,	42 0	90 52	9 15	"	−15
Iron ore,	41 55	90 40	8 20	"	+31
Wapsipinnicon,	41 45	90 23	8 22	"	+16
Lost Grove,	41 39	90 9	8 10	"	+18

Central position, latitude 42° 28′ N., longitude 90° 25′ W., $\delta = -1°.8046$, i. e. $-8°\ 48'.3$, $x = -.00344$, $y = +.014564$. Mean of the differences at ten northern stations $+1'.1$; seventeen southern $-0'.7$; seven stations having the greatest computed variation $+0'.1$; six least $+2'.7$; fourteen intermediate $-1'.2$.

TABLE XII.—11 *Stations.*

Station.	Latitude.	Longitude.	Variation.	Date.	Differences.
Keweenaw Point,	47° 25′	88° 30′	−5° 37′	1840	− 1′
Riviere du Gres,	47 22	88 34	5 24	"	+15
Ontonagen River,	46 57	89 49	6 33	"	+17
La Pointe,	46 45	91 22	8 33	"	−10
Montreal River,	46 41	90 46	7 43	"	+ 3
Grand Marrais,	46 40	86 1	3 29	"	−35
Parisien Island,	46 32	84 38	1 11	"	+15
Miner's River,	46 32	86 35	3 39	"	−13
Sault St. Marie,	46 31	84 19	1 25	"	−19
Montreal Channel,	46 18	83 40	0 12	"	+10
Drummond Isle,	45 58	83 50	0 9	"	+18

Central position, latitude 46° 41′ N., longitude 87° 6′ W., $\delta =$ 4°.00489, i. e. $-4°\ 0'.3$, $x = -.003988$, $y = +.024886$. Mean of the differences at the six most northern stations $-1'.8$; five southern $+2'.2$; three most easterly $+3'.0$, three most westerly $+3'.3$; five intermediate $-3'.8$.

Collecting together the preceding results, we obtain the following table, in which column third represents the variation for places whose latitude and longitude are given in columns first and second; column fourth, shews the direction of the lines of equal variation; column fifth, the increase of variation in the normal direction for sixty geographical miles; and column sixth, the distance of the lines of equal variation expressed in geographical miles.

Latitude.	Longitude.	Variation.	Direction of lines.	Increase.	Distance of lines.
44°55′ N.	69°31′ W.	+13°13′.9	N. 50°40′ W.	118′.90	30.28
43 24	72 57	+ 8 26 .9	N. 39 13 W.	90 .29	39.87
42 5	75 12	+ 5 5 .0	N. 26 36 W.	74 .77	48.15
43 49	84 4	− 2 20 .6	N. 10 59 W.	89 .09	40.41
40 53	81 2	− 0 36 .2	N. 22 19 W.	64 .14	56.13
39 52	83 40	− 3 30 .8	N. 11 24 W.	52 .92	68.03
32 46	81 55	− 4 47 .4	N. 20 17 W.	67 .65	53.21
32 48	84 19	− 5 2 .7	N. 7 27 W.	22 .06	163.16
32 6	91 8	− 7 57 .5	N. 8 56 W.	21 .12	170.42
39 12	89 22	− 7 35 .1	N. 5 53 E.	31 .60	113.94
42 28	90 25	− 8 48 .3	N. 13 17 E.	53 .87	66.82
46 41	87 6	− 4 0 .3	N. 9 6 E.	90 .73	39.68

From these data are computed the positions of the following lines of equal variation.

Variation.	Lat.	Lon.	Direction.	Variation.	Lat.	Lon.	Direction.
+14°	45°25′.1	69°31′	N. 52°30′ W.	−3°	30°52′	82°53′.6	N. 13°35′ W.
13	44 45 .9	69 31	N. 50 7 W.	4	46 41	87 5 .4	N. 9 6 E.
9	43 24	72 18 .0	N. 41 17 W.	4	39 52	84 24 .0	N. 9 20 W.
8	43 24	73 28 .8	N. 37 32 W.	4	32 46	81 1 .7	N. 20 17 W.
6	42 5	74 5 .4	N. 27 17 W.	5	32 48	84 10 .3	N. 7 26 W.
+ 5	42 5	75 18 .0	N. 26 32 W.	8	32 6	91 17 .0	N. 8 57 W.
− 2	43 49	83 44 .4	N. 12 16 W.	7	39 12	87 55 .6	N. 3 24 E.
3	43 49	84 41 .5	N. 8 31 W.	8	39 12	90 23 .4	N. 7 39 E.
0	40 53	80 13 .5	N. 24 35 W.	8	42 28	89 10 .1	N. 10 16 E.
1	40 53	81 33 .8	N. 20 50 W.	9	42 28	90 43 .2	N. 14 1 E.

The preceding positions are each determined from a single group of observations, independently of all the others. In projecting the lines upon a map, some anomalies will be perceived as to the direction of the lines and their distance from each other. The most remarkable of these is the line $-4°$ in latitude 32° 46′. The

observations at some distance from this line would lead us to look for it about three quarters of a degree farther west than the position here assigned.

P. S. *Seventeen hundred Errata in Hutton's Table of Products.*

In solving equations of condition by the method of minimum squares, I have been accustomed to form the products by the aid of Hutton's Table. I entertained no doubt of its accuracy, until, on verifying one of my operations, I discovered in the Table an error which I presently perceived to run through almost an entire folio page. The case occurs on page 20, the product of 361 by 15 being given 5315 instead of 5415, and as the products appear to have been derived from each other by addition, this error is propagated to the bottom of the page, affecting thus 1700 products.

ART. X.—*On the Want of Identity between Microlite and Pyrochlore;* by CHARLES UPHAM SHEPARD, M. D., Prof. Chem. in the Medical College of the State of South Carolina.

PROF. SILLIMAN having apprised me on my recent arrival in town, that a paper was about to appear in this Journal by Messrs. TESCHEMACHER and HAYES of Boston, the object of which would be to establish the identity of Microlite with Pyrochlore, and being permitted by the editors, I hasten to reply in the same number.

The opinion of the identity originated with Mr. TESCHEMACHER; and is expressed without the slightest reserve, resulting as he remarks, "from a close examination of several crystals of the mineral named Microlite;" but Mr. T. singularly enough omits altogether, the results of any researches bearing on the point to be established, if we except the mention of a mineralogical property which is simply descriptive, never characteristic, viz. the circumstance that in Microlite, the color is "transparent (!) straw-yellow to brick-red and dark brown!"* For the full confirmation of his opinion, he then refers to the analysis of Mr. HAYES, which was undertaken at the request of the Chemical Society of Boston.

* In this account of color however, my specimens do not agree.

I shall first exhibit the mineralogical differences between the two minerals, in order to show the fallacy of any attempt to unite the two species on natural-history grounds; and shall then inquire what support the new view acquires from chemistry.

Pyrochlore.	*Microlite.*
Crystals, unmodified regular octahedrons.	Crystals, regular octahedron, with edges truncated and angles surmounted by four-sided pyramids, whose faces correspond to the octahedral planes.
Cleavage, none (fracture conchoidal).	Cleavage, octahedral, distinct.
Lustre, resinous to vitreous.	Lustre, resinous.
Color, deep red-brown to black.	Color, pale honey-yellow. Surfaces of crystals often reddish or blackish brown from implanted minerals.
Streak, brown.	Streak, pale yellowish white.
Translucent on the edges, to opake.	Semi-transparent to translucent.
Hardness = 4.75.	Hardness, 5.25 (readily scratches Pyrochlore).
Gravity = 4.20 to 4.25.	Gravity = 5.485 to 5.562.*

I consider it apparent therefore, that all attempts to unite two minerals, whose individuals afford no transition-links to constitute the passage of insensible gradation, in properties so essential as specific gravity, internal structure and hardness, must prove una-

* The specific gravity as heretofore quoted, was 4.75 to 5.00; but very opportunely for this examination, I had brought with me from my Charleston cabinet an excellent crystal, weighing 3.805 grains; and possessing one of Robinson's best eight inch-beam balances (which turns readily with one thousandth of a grain), I was able to correct the specific gravity, as above. The original determination of this property was effected by means of a balance much less sensitive, and on a crystal whose weight was only four tenths of a grain. Indeed, this was the largest crystal I had seen, when I described the species. Observing however, that my crystal of 3.805 grains had two of its octahedral sides pitted from the implantation of calcareous spar and green tourmaline, I at first took its specific gravity with these impurities attached. The result was 5.485. I then cleaved off these faces, thereby reducing the weight of the crystal to 2.410 grains, when its gravity rose to 5.562.

vailing; and according to the rules of forming the species in mineralogy, Microlite must still stand distinct from Pyrochlore.

Let us now turn to a review of the analysis of Mr. HAYES. This gentleman has not in any form, alluded to a paper of mine, entitled "*Chemical Examination of Microlite*," and published in Vol. XXXII, p. 338, of this Journal. To save the reader the trouble of referring to that article, I will simply quote from it so far as to say, that I found the Microlite to be a columbate of lime and yttria, with moisture and traces of uranium and tungstic acid. The details of the examination were fully given in that communication; and in particular, the proofs that the mineral was a *columbate*. My surprise was therefore not inconsiderable, to find the subject of my former labors held up in a light so novel, as that of being a salt of a totally new and non-isomorphic genus.

The paper of Mr. HAYES in support of his views, is out of proportion full on points, where the evidence is unsatisfactory; and silent, where the reader might appreciate its value as affecting the point at issue: for I hold the blowpipe characters of complex bodies like the Microlite to be simply sufficient for furnishing the chemist to tolerable guesses, in aid of subsequent and more certain experiments with chemical reagents, upon the decomposed and separated ingredients of the mineral. After nearly a page of blowpipe results, many, if not all, of which would be likely, in other hands (with different lamps, blowpipes, and lungs, as well as different sized specimens and proportions of fluxes), to be afforded from specimens of half a dozen other species as well as from Microlite, we have the steps of the analysis given in the following words. "One grain of the mineral which had been dried was decomposed; the titanic acid carefully separated and dried, it weighed 80; this had the chemical characters of pure titanic acid.

"The solution of the oxides from the titanic acid gave a precipitate of sulphate of tin, when treated with sulphohydric acid, and the sulphate* oxidized before the blowpipe gave with soda a globule of tin. Sulphohydrate of ammonia gave a black precipitate, which when roasted contained oxides of iron and uranium, with traces of oxide of cerium. The fluid remaining gave

* The sulphuret of tin is here referred to, by Mr. HAYES, in this as well as in the previous line.

with oxalate of ammonia, a precipitate which was converted into sulphate of lime, equivalent to 0.08 lime. Thus,

Titanic acid,	. . . . .	80.
Oxide of tin, iron, cerium, uranium,	. . . . .	11.8
Lime,	. . . . .	08.2
		100.0

"This mineral is therefore identical with that analyzed by Wöhler. The absence of protoxide of manganese and water, and the smaller proportion of oxide of iron in this specimen, as indicated by the blowpipe experiments, will account for the larger proportion of titanic acid given in the analysis." p. 34.

Then follows a quotation of the analysis of Pyrochlore by Wöhler, with which Mr. Hayes identifies his own results upon the Microlite. But when we find, on comparing the two analyses, a difference of more than 17 per cent. in the acid, and of one third in the principal base, as well as a wide discrepancy in volatile matter, and call to mind that these results are deduced from a single trial, and that upon one grain's weight of the mineral, we must believe, that the conclusion of Mr. Hayes cannot be sustained upon such slender grounds; and inasmuch as Mr. Teschemacher refers to the analysis for the confirmation of his views, is it not possible that Mr. H. in turn, has unconsciously been indebted to the mineralogical evidence for a portion of his confidence?

In order to speak from present knowledge on the subject, although I have no reason to doubt the correctness of former results, I subjected 2.142 grains of the above mentioned crystal to the following examination; premising however, that my inquiry was chiefly directed to the proofs of columbic acid in the mineral, and not to a rigid determination of proportions in the different constituents.

A. The powdered mineral was white, with only a faint tinge of yellow. Heated for half an hour to redness, it scarcely changed in color; and lost 0.060 in weight, which equals 2.801 per cent. It was then intimately mixed with six times its weight of bisulphate of potash, and the mixture maintained in fusion for half an hour. Successive portions of water were boiled upon the

fused mass for upwards of half an hour, until every thing soluble was taken into solution. A dense, white powder remained undissolved.

B. Hydrosulphate of ammonia produced, in a portion of the solution A, a precipitate, without sensible discoloration, and which, from former proofs in my paper of 1835, was taken for yttria. The remainder of the fluid was then precipitated by oxalate of ammonia, the precipitate ignited, redissolved in hydrochloric acid, the yttria thrown down by ammonia, and the lime by oxalate of ammonia, which on ignition, weighed 0.032 or 1.49 per cent.*

C. The white, insoluble matter A, was digested for some time in a saturated solution of hydrosulphate of ammonia, the operation being conducted on a filter in the way recommended by Berzelius. The insoluble matter was blackened by the affusion of the hydrosulphate.

D. The sulphohydric fluid was decomposed by nitric acid and heat; hydrochloric acid was added; no precipitation ensued. But the fluid, on the addition of ammonia, afforded a precipitate of peroxide of tin, which after ignition, weighed .001, which equals 0.047 per cent. The oxide was reduced with carbonate of soda on charcoal, to the metallic state.

E. The blackened powder C was treated with dilute hydrochloric acid, and gently warmed. The filtered solution was precipitated by ammonia, and ignited. The peroxide of iron was apparently blended with traces of yttria. It weighed 0.022 or about 1 per cent.

F. The insoluble matter, washed by hydrochloric acid (E) was drenched upon the filter, with an abundance of hot water: it showed no tendency to pass through the filter in a milky state, as titanic acid is well known to do, under such circumstances. It was ignited in a platina crucible, and exhibited *a white color while hot*, as well as after cooling. Its weight after some accidental losses, was 1.052 gr. = 49.11 per cent. But I still regard my former determination of the proportion of acid, and which was 75.70 per cent., to be very near the truth.

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* The calcareous content here obtained is quoted only as an approximation; but falling so much below what I previously found, and considered in conjunction with my observation of implanted calcareous spar upon the crystal, it is possible that lime may yet prove to be an accidental ingredient in the mineral.

A portion of the acid was fused with carbonate of potash in a platina crucible; water was boiled upon the mass, whereby *a complete solution was effected.* To a portion of the solution, hydrochloric acid was added. It first occasioned a cloudiness, *but subsequently the fluid became clear. The same effect was produced by oxalic acid.* Ferrocyanide of potassium afforded with the oxalic solution, *a yellow precipitate*, and the tincture of nut-galls with the same, a rich *orange precipitate.*

A portion of the acid was fused with biphosphate of soda on a platina hook, in the inner flame of the blowpipe: a transparent glass was obtained, which was *colorless while hot, as well as after cooling.* Fused with soda before the blowpipe, an opake, white bead was obtained.

My conclusion concerning the composition of the Microlite, derived from the foregoing examination, coupled with that in 1837, is this, that it is a columbate of yttria and lime, with a little moisture, adventitious traces of iron, tin, tungstic acid, and uranium.

I do not possess enough of the mineral to enable me to undertake its analysis: but it is a question which I regard with interest, and shall welcome its final settlement from whatever quarter it comes; though I must be excused, in the face of such evidence as I have already cited, from acquiescing in the mere declaration of any authority however high, that its prime ingredient is titanic, in place of columbic, acid.

To show that a zeal to defend a species because it was put forth by myself, is not the motive for the present reclamation, I am free to say, that I have long perceived several striking analogies which point towards an identity between Microlite and the Yellow yttrotantalite of Ytterby, although "a close examination" of several points in the history of the latter substance, yet requires to be made, in order to establish the truth of such a conjecture.

New Haven, May 15, 1842.

The remarks of Prof. Shepard having been communicated to Mr. A. A. Hayes, he candidly admits their correctness.—Eds.

ART. XI.—*Additional Objections to Redfield's Theory of Storms;* by ROBERT HARE, M. D., Professor of Chemistry in the University of Pennsylvania.

33. IN a communication to the American Journal of Science, for January, I endeavored to point out various errors and inconsistencies, in the theory of storms proposed by Mr. Redfield, or in the reasoning and assumed scientific principles on which that theory had been advanced. Of these errors I will present a brief summary.

34. I conceive that Mr. Redfield has erred, in ascribing atmospheric currents, whether constituting trade winds or storms of any kind, "*solely to mechanical gravitation as connected with the rotatory and orbitual motion of the earth.*"*

35. In ascribing those atmospheric gyrations of which according to his hypothesis all storms consist to "*opposing and unequal forces,*" without specifying the nature or accounting for the existence of these forces, although implying that they originate as above mentioned.

36. In assigning to all fluid matter a tendency to "*run into whirls and circuits, when subjected to opposing and unequal forces,*" when this allegation, if true at all, can only be so in some peculiar cases of such forces.

37. In alleging all storms to be whirlwinds, and yet representing a "*rotative movement in air as the only cause of destructive winds and tempests,*" *so that a whirl is the only cause of a whirlwind.*†

38. In averring, in reference to the alleged gyration and vortical force of tornadoes which are by him treated as hurricanes in miniature, that "*all narrow and violent vortices have a spiral involute motion quickening in its gyration as it approaches the centre or axis of the whirl,*" whereas it must be evident that when gyration in a fluid does not result from a contemporaneous centripetal force, arising from an ascending or descending current at the

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* See paragraph 43 of this essay.

† This Journal, Vol. XXI, p. 192: *Storms and hurricanes consist in the regular gyratory motion or action of a progressive body of atmosphere, which action is the sole cause of the violence which they may exhibit.*

If we understand Mr. Redfield, he assigns the whirlwind as the cause of the "violence"—not as the cause of the "whirlwind"—the two words not being synonymous.—EDS.

axis, but on the contrary exists only in consequence of a momentum previously acquired, the consequent velocity in any part of the mass affected, will be less in proportion to its proximity to the axis: also that the only case in which it can increase with its proximity, is where the mass is fluid and it proceeds from some competent cause acting at the axis.

39. In representing that the upward force of tornadoes is the *effect* of a vortical or gyratory action,* when it must be quite plain that a "*vortical*" action or whirling motion instead of causing the air upon the terrestrial surface, necessarily subjected by it to a centrifugal force, to seek the centre, would induce that portion of the atmosphere which should be above the sphere of the gyration, to descend into the central space rarefied by the centrifugal force.

40. In admitting the gyration, which he considers as the cause of storms, to quicken as it approaches the axis of motion, without perceiving that this characteristic is irreconcilable with his inference that gyration caused by forces acting remotely from the axis is the proximate cause of all the phenomena in question.

41. In the last number of the American Journal of Science, (for April, 1842,) Mr. Redfield has hinted that the pains which I have taken to confute his doctrines, are disproportioned to the low estimation in which I have professed to hold them. I should be glad if this view of the subject should render my strictures agreeable to him; and am sincerely sorry that, consistently with truth, I cannot directly take a course more favorable to his meteorological reputation. I admit that his essays have met with an attention which may have justified him in pluming himself on their success. Had it been otherwise, I should not have thought it worth while to enter the lists. It strikes me, however, that a fault now prevails which is the opposite of that which Bacon has been applauded for correcting. Instead of the extreme of entertaining plausible theories having no adequate foundation in observation or experiment, some men of science of the present time are prone to lend a favorable ear to any hypothesis, however in itself absurd, provided it be *associated with observations.* But to proceed with the "reply," so called, the author alleges that in the absence of "*reliable facts and observations*" in support of my

* See paragraph 75 of this communication.

objections to what he considers as the "*established character of storms,*" he had hesitated to answer them. This cannot excite surprise, when it is recollected "that the whole modern meteorological school," and likewise "Sir John Herschel," are accused by him of a "*grand error,*" in not ascribing all atmospheric winds "*solely to the gravitating power as connected with the rotary and orbitual motion of the earth.*"

42. For this denunciation he has no better ground than that on which he deems his theory to be above my reach, that is to say, because himself and others have made some observations shewing that in certain storms, agreeably to log-book records, certain ships have had the wind in a way to indicate gyration. Being under the impression, that in many instances no better answer need be given to Mr. Redfield's opinions than that created in the minds of scientific readers by his own language, I will here quote his denunciation of the opinions of the meteorological school and of Herschel.

43. "*The grand error into which the whole school of meteorologists appear to have fallen, consists in ascribing to heat and rarefaction the origin and support of the great atmospheric currents which are found to prevail over a great portion of the globe.*" * * * "*An adequate and undeniable cause for the production of the phenomena * * I consider is furnished in the rotative motion of the earth upon its axis, in which originate the centrifugal and other modifying influences of the gravitating power, which must always operate upon the great oceans of fluid and aërial matter, which rest upon the earth's crust, producing of necessity those great currents to which we have alluded.*" (See this Journal, Vol. xxviii, p. 316.) Speaking of Sir John Herschel's explanation of the trade winds and others, Mr. Redfield alleges, "*Sir John has however erred, like his predecessors, in ascribing mainly, if not primarily, to heat and rarefaction those results which should have been ascribed solely to mechanical gravitation as connected with the rotative and orbitual motion of the earth's surface.*"

44. Is it not surprising that it did not occur to the author of these remarks, that an astronomer so eminent as Sir John Herschel would be less likely than himself to be ignorant of any atmospheric influence resulting from gravitation or the diurnal and annual revolutions of our planet—and that when he found him-

self in opposition to the whole school of meteorologists, a doubt did not arise whether the "*grand error*" was not in his views of the subject instead of that which they had taken?

45. It seems to have been forgotten, that all the aqueous portion of the terrestrial surface being, no less than the superincumbent atmosphere, subjected to the gravitating power and the rotary and orbitual motions of our planet, no impulse can be given to the one which is not received by the other; and that as the heavier the fluid the greater the influence, if this be competent to create gales in the atmosphere, it must be no less competent to produce torrents in the ocean. Moreover, do not his opinions conflict not only with the *whole school of meteorologists*, but also with a portion of the modern school of geology? Agreeably to the last mentioned school, the external portion of the earth consists of a comparatively thin shell of earth and water floating upon an ocean of matter kept in fusion by heat; the oblate spheroidal form of our planet being due to the perfect equilibrium of the "*gravitating, rotary, and orbitual*" forces which are most inconsistently represented by Mr. Redfield, as having upon the atmosphere an opposite effect.

46. But notwithstanding the opinions expressed in the paragraphs above quoted, and in the following, Mr. Redfield alleges in his reply to my objections that it is an error to consider him as rejecting the influence of heat. It is very possible that his opinions may have changed since he read my "*objections*;" but that he did reject the influence of heat when the preceding and following opinions were published must be quite evident. "*Were it possible to preserve the atmosphere in a uniform temperature all over the surface of the globe, the general winds would not be less brisk than at present, but would be more constant and uniform than ever.*" (This Journal, Vol. xxviii, p. 318.)

47. Mr. Redfield alleges that the proper enquiry is, *What are storms?* not *How are storms produced?* And yet it will be found that his great object has been to show that they arise from gyration caused by unequal forces generated in some inexplicable mode, by gravitation and the complicated motions of our planet. But suppose that before ascertaining *how* fire is produced, chemists had waited for an answer to the question *what is fire*, how much had science been retarded? I do not therefore blame Mr. Redfield for pursuing both inquiries simultaneously,

inconsistently with his own rule above stated, but I am astonished that he should, without any new experiments or any demonstrations, by an *ipse dixit* undertake to make a novel application of the gravitating power, and the forces arising from the earth's motion; and to inform one of the most eminent astronomers of the age that he had committed an error in overlooking their all-important meteorological influence.

48. Turning from an endless controversy with a writer with whom I differ respecting first principles, I shall address myself to that great school of meteorologists who concur with me in the "*grand error*" of considering heat and electricity as the principal agents of nature in the production of storms, and who do not concur with Mr. Redfield in considering gravitation and the earth's annual and diurnal motion as the great destroyer of atmospheric equilibrium. So far as it may conduce to truth, I shall incidentally notice some parts of Mr. Redfield's reply; but my main object will be to show the inconsistency of his theoretic inferences with the laws of nature, and the facts and observations on which those inferences are alleged to be founded. To follow him in detail through all the misunderstandings which have arisen, and which would inevitably arise during a continued controversy, would be an Ixion task.

49. Speaking of the trade winds and monsoons, our author states: "*It is to the operation and effect of these great and regular moving masses,*" that we are disposed mainly to ascribe the more active and striking meteorological phenomena of every latitude. * * And again, "*At these seasons the northern margin or parallels of the trade winds sweeping towards the gulf, must necessarily come in collision with the great archipelago of islands which skirt the Carribean Sea,*" * * * (this Journal, Vol. xx, p. 31,) "*the obstruction which they afford produces a constant tendency to circular evolution.*" * * * "*These masses of atmosphere thus set into active revolution continue to sweep along the islands with increased rapidity of gyration until they impinge upon the American coast.*" "*We have assumed that the leading storms of the northern and western Atlantic and the American coast originate in detached and gyrating portions of the northern margin of the trade winds, occasioned by the oblique obstruction which is opposed by the islands to the direct progress of this part of the trade, or to the falling of the northerly and eddy wind*

upon the trade, or to these causes combined." (This Journal, Vol. xx, p. 48.)

50. I trust it will be sufficiently evident, that although great and regularly moving masses of air, by encountering obstructions, may undergo a transient deflection, and that a portion accidentally caught in a strait with high cliffs on either side might like the tide in the Bay of Fundy, acquire a local and temporary acceleration, yet that it would be utterly impossible for a durable whirlwind to be thus excited. Obviously for the endurance of a whirl, if not for its production, the continuous application of at least two forces would be requisite, of which one must be endowed with a centripetal efficacy in order to counteract the concomitant centrifugal momentum. It will be evident that although a local obstruction may cause an eddy or whirl in its vicinity, the rotary momentum thus created must soon be exhausted. But admitting that a blast by being deflected by an island could become a permanent whirlwind, obviously the resulting velocity could not be so great as that of the generating current. The moderately blowing trade wind could not, by contact with an inert body, acquire an increase of velocity adequate to form a furious hurricane capable, as represented, of travelling circuitously for more than two thousand miles.

51. The hurricane once created, agreeably to the imagination of Mr. Redfield, its subsequent progress is described in the following language: "*This progress still continues while the stormy mass is revolving around its own moving axis; and we can readily comprehend the violent effects of its unresisted rotation, while this velocity becomes accelerated by nearly all the oblique forces and perhaps resistances of the circumjacent currents or masses of moving atmosphere. These storms cover, at the same moment of time, an extent of contiguous surface, the diameter of which may vary from one to five hundred miles, and in some cases have been much more extensive. They act with diminished violence towards the exterior, and with increased energy towards the interior of the space which they occupy.*" (This Journal, Vol. xxv, p. 114.)

52. Thus it is assumed, that a mass of air from "*one to five hundred miles in diameter*" being made to whirl with the velocity of a most furious gale, is not only "*unresisted*" by the waves, forests, hills, and mountains, which it may encounter, but is actually "*accelerated by nearly all the oblique forces and perhaps* RESIS-

TANCES" which it may meet. Yet it must be quite clear, that any reaction with currents not moving the same way, or moving with an inferior velocity, or obliquely, could only be productive of retardation.

53. The following inconsistencies will shew how far Mr. Redfield's account of the phenomena of storms is to be deemed sufficiently accurate or consistent to overset the established principles of science.

54. "*The rotation of a continued whirlwind involves not only changes in the position and condition of its constituent particles, but a constant accession of the exterior atmosphere to the body of the whirlwind, together with a discharge equally constant spirally at one extremity of its axis of rotation.*" (Franklin Journal, Vol. 19, p. 122.) Ibid., p. 120: "*Nor is it my intention to deny any movement or upward tendency at the centre of a whirlwind storm, for of such a movement, apart from theory, I have long since obtained good evidence.*" Ibid., p. 122: "*In regard to the depression of the barometer which I have ascribed to the rotary action of whirlwind storms, Mr. Espy has himself shewn, that the centrifugal action in a storm which gyrates horizontally must tend to withdraw or rarefy the air at the centre by causing a transfer or accumulation towards the exterior of the storm, thus causing a higher state of the barometer around the exterior border, than at the centre of the gale. This connexion and result is in strict accordance with the facts of the case as exhibited in all storms of this character so far as my observations and information extend.*"

55. On opposite sides of the same leaf we find the preceding quotations. Agreeably to the first, there is a constant accession of air from the exterior atmosphere to the body of a whirlwind, attended by an upward force and compensated by a discharge at one extremity of its axis of rotation; agreeably to the last, the centrifugal action tends to withdraw the air of the centre by causing a transfer or accumulation towards the exterior border.

56. In tornadoes the author admits the undeniable existence of an ascending column at the axis (75), and we are told that a whirlwind storm "*operates in the same manner and exhibits the same general characteristics as a tornado;*"* but this idea is evi-

* This Journal, Vol. xxv, p. 117.

dently irreconcilable with that of a withdrawal of air from the centre, agreeably to one of the contradictory allegations above cited.

57. Nor are the following observations more consistent. "*During the passage of these eddies or storms over the place of observation the barometer sinks while under their first or more advanced portions and rises as they pass over or recede.*" (This Journal, Vol. xxv, p. 129.) "*The barometer, whether in higher or lower latitudes, always sinks while under the first portion or moiety on every part of its track excepting perhaps its extreme northern margin.*" "*The mercury in the barometer always rises again during the last portion of the gale and commonly attains the maximum of its elevation on the entire departure of the storm.*"

58. But if "*a higher state of the barometer be created around the exterior border of a whirlwind than at the centre,*" and if of necessity the exterior border be first encountered, how does it happen that precisely about this space, agreeably to the statement last quoted, the barometrical column should sink? And if, agreeably to the statement quoted previously, the air be rarefied about the centre and accumulated towards the border, in passing from the one border to the other through the centre, would not the mercury in the barometer first rise, then sink, and afterwards rise again, instead of falling during its exposure to one moiety of the storm, and rising during exposure to the other?

59. It may be presumed, that respecting the state of the barometer and the movement of the air, within the sphere of his whirlwinds, Mr. Redfield's views are not in accordance with any settled notions. His theory leads to the idea of a centrifugal force, rarefying and removing the air from the centre, while his observation of the ascending current in tornadoes has tended to create an opposite impression.

60. Considering the inconsistencies of Mr. Redfield's "*reliable* facts and observations," I hope I may be allowed to show what ought to ensue according to his own premises. Evidently in a whirlwind, constituted as are those to which we have reference, the centrifugal force will cause an accumulation of air towards the exterior until the otherwise uncounteracted pressure of the accumulation, tending to restore the level, is in equilibrio with the centrifugal force. Moreover, the reaction of the fluid lying in the same plane beyond the whirl, will cause the fluid to be

higher, or if elastic, denser at an intermediate point than the general level. In the case of an elastic fluid like the air, condensation will be substituted for accumulation, and will amount to the same thing in effect. It would follow, that as the whirl should advance, the barometer would rise until the front limb of the zone of greatest condensation should arrive: subsequently it would fall till the central space should arrive, and then another rise and subsequent fall would ensue during the approach and departure of the rear limb of the zone of greatest condensation.

61. One fact is mentioned among the contradictory evidence above quoted, which seems to be supported by universal experience. The barometrical column does fall at the commencement of a storm, and of course this fact does not accord with the idea that storms are whirlwinds produced by mechanical forces remote from the axis and attended necessarily by a centrifugal action which would accumulate the air towards the exterior.

62. Respecting another characteristic, the "*reliable facts and observations of our theorist*," are no less irreconcilable than in the case last considered. I allude to the changes in the direction of the wind which ensue from the commencement to the end of a hurricane, and especially on the outer limbs on each side of the line of progression.

63. Thus speaking of the progress of a storm from southwest to northeast along the coast of the United States, he alleges that "*along the central portions of the track the first force of the wind is from a point near southeast, but after blowing for a certain period it changes* SUDDENLY, *and* USUALLY, AFTER A SHORT INTERMISSION, *to a point nearly or directly opposite to that from which it has previously been blowing; from which opposite quarter it blows with equal violence till the storm has passed over or abated.*" Again, "*It is demonstrably evident, that at any point over which the centre of a whirlwind may pass, the wind must* SUDDENLY *change to a direction almost exactly opposite to that which has been felt during the preceding part of its progress.*" (This Journal, Vol. xx, p. 22.) "*It sometimes happens when the central portion of an extensive storm passes over or near the point of observation that the comparative calm or lull which prevails about the apparent centre of rotation,* is preceded by a gradual rather than a sudden abatement of the wind. "*Every experienced navigator will shrink with instinctive apprehension from*

the very idea of those moments of awful stillness which place him in the central vortex of the hurricane." (Franklin Journal, Vol. xix, p. 116, and this Journal, Vol. xx, p. 47.)

64. Amid the neutralization of evidence which inevitably results from the conflicting statements above quoted, I will endeavor to point out the results which ought to ensue if the inferences of the advocates of the whirlwind doctrine were correct.

65. When a rotary motion is communicated to a solid by a force applied to any part whatever, the tangential velocity at any point will be directly as its distance from the centre. In a fluid, when the force productive of rotation is applied at any point remote from the axis, the motion at the axis can be no quicker than in the case of a solid, but may be slower, since the parts do not of necessity move simultaneously. In the case of a fluid body kept in motion by a momentum resulting from forces previously applied, as in the instance of a Redfield whirlwind, any zone, which has been made to revolve by the direct application of force, will be retarded until it causes, in the adjoining zones, a due proportionable velocity. This will not be attained until the whole rotates like a solid. There is however this difference, that the external portions of the whirling zone being pressed by the centrifugal force against other portions of the same fluid, the one will conflict with the other, so as to cause the velocity to be communicated and to lessen outwards from the zone (in which the moving power is or has been applied) till it becomes insensible. This result must ensue the more speedily, since the momentum receives no reinforcement, while the mass which it actuates increases with the square of the distance from the axis.

66. It follows that at any station over which, or near which the centre of a whirlwind shall pass, there will be a breeze scarcely perceptible at first, but which will strengthen gradually into a gale of preëminent fury. Subsequently a declension must take place until the centre arrives; here again there would be no perceptible wind. The centre having moved away, the wind must increase again to a maximum of force and then decline to a breeze.

67. Mr. Redfield alleges, that the storm of August 17th, 1830, whirling to the left, travelled from southwest to northeast at the rate nearly of twenty seven miles per hour; that its greatest diameter was from five hundred to six hundred miles; that of its

severe part was from one hundred and fifty to two hundred and fifty miles. Thus it may be assumed, that in order for an observer to be exposed successively within the severe portion on the southeastern and northwestern limbs, the storm would have had to move at least one hundred miles, requiring nearly four hours. Hence if the storm in question were a whirlwind, instead of the change having been sudden, several hours would have been required for its gradual accomplishment.

68. To prove therefore that a sudden change ensued from one violent wind to another of the same character blowing in an opposite direction, is to demonstrate that the storm in which it took place was not an extensive whirlwind. Yet this characteristic is universally admitted to belong to hurricanes, and especially to those upon our territory in which a southeaster is followed by a northwester. Hence the seaman's saying which Mr. Redfield sanctions in quoting, "*a northwester does not remain long in debt to a southeaster.*"

69. But if the storm above alluded to moved from southwest to northeast as Mr. Redfield's doctrine requires, and the velocity of the wind on the southeastern and northwestern limbs of the whirl were as great as described, that on the southwestern side must have been more than a fourth more violent, having the general motion of the storm, superadded to its appropriate gyrating velocity. Yet there is no evidence that any such superiority existed. On the contrary the violence of the southeaster and northwester seems to have been preëminently the object of attention.

70. Agreeably to Mr. Redfield, hurricanes have a diameter varying from one mile to five hundred miles, the diameter of the severe part of the storm of August, 1830, being from one hundred and fifty to two hundred and fifty miles. Of course a portion of the eastern as well as the western limb of such a storm might be comprised between the Alleghany mountains and the Atlantic shore; and in no case would the inner portion of the southeastern and more violent limb be beyond the cognizance of our merchants and insurers. It would be a matter of course that in every violent northeast gale, arising as represented from the progression of the northwestern limb along our coast, fears would be entertained lest vessels, inward bound, should be met by a much more violent southwester. But experience shews, that every

northeaster brings in a crowd of vessels having only to complain of the violence not of the direction of the wind.

71. It has been assumed, that a storm whirling to the left and travelling northeasterly, must, at stations passing nearly under the centre, first blow as a southeaster and afterwards gradually change to a northwester. Meanwhile on the southeastern or left limb it will blow only from the southwest, and on the northwestern or right limb it will blow only from the northwest. Consistently, when the storm travels from southeast to northwest, as hurricanes are represented to travel in proceeding from the sphere of their origin in the West Indies to the coast of North America, it will at stations within a certain distance of a line described by the centre, blow from the northeast first. On the southwestern limb it will blow first as a northwester; on the northeastern limb as a southeaster. Moreover, that on the last mentioned limb the greatest violence will occur, since the general motion of the whirlwind will there coöperate with that of the whirl. Yet in the following paragraph Mr. Redfield informs us, (this Journal, Vol. xxv, p. 128,) that "*In the West Indies, hurricanes begin to blow from a northern quarter of the horizon, and then changing to west and round to a southern quarter and then their fury is over.*"

72. This account of the direction of the wind in West India hurricanes agrees with that quoted by Espy from Edwards's History of Jamaica, Vol. 3d: "*All hurricanes begin from the north, veer back to west-northwest, west, and south-southwest, and when got to southeast, the foul weather breaks up.*"

73. It must be evident, as stated among my "*objections*," that when a whirl is first originated, whether it describe a helix, *as would result from its progressive circular motion, or a circle, as represented by Mr. Redfield in his charts*,* it must at thirty two stations equidistant from each other and the centre of gyration, blow from as many points of the compass. However, when once *under way*, it being granted that the whirling is always from right to left, evidently at any station near the line described by the centre, it will begin to blow at right angles to that line or from the northeast. As the centre advances this wind would gradually subside, and, after the centre should have gone by, it would begin to blow from the southwest with increasing force till the se-

* Franklin Journal, Vol. 19, p. 120.

vere part of the southeastern limb should be passed. On this part of the track only one change would take place. But at two stations sufficiently remote from the central line, the wind in passing from northeast to southeast would undergo an intermediate deviation, but necessarily of an opposite nature, since for the same reason that at one, there would be first more northing and then more westing, at the other, there would be more easting and more southing, *pari passu*. But on the outward northeastern and northwestern limbs, or in other words, on the right and on the left external borders, there would be no change. On the one it would blow from the northwest only, on the other only from the southeast. On this last mentioned limb the blast would be preëminent in violence, since in that direction the gyrative and progressive motion of the whirlwind would concur.

74. Nevertheless, agreeably to the observations which have lifted the whirlwind theory above the reach of my strictures, hurricanes in the West Indies begin (*at every place*) from a northern quarter, and changing first west, and afterwards to a southern quarter, terminate their fury. Thus, agreeably to the evidence of Mr. Redfield, the fury of the hurricane is the least where, according to his hypothesis, it should be the greatest.

75. Having cited and endeavored to shew the futility of the only explanation which can be found in Mr. Redfield's essays of the mode in which whirlwinds are induced, I will quote a passage from which it would seem that they are supposed capable of being self-induced. Whence it would follow, that while free from any external cause, his "*rotary movement, which is the sole cause of destructive winds and tempests,*" could spontaneously, excite itself and the adjoining elements into a destructive commotion. From this statement, it appears that the author was not aware that in making it he gave a blow to his favorite idea of opposing and unequal forces, arising from gravitation and terrestrial motion, being the cause of stormy atmospheric gyration.

76. "*We may observe, also, that whirlwinds and spouts appear to commence gradually and to acquire their full activity without the aid of any foreign causes; and it is well known they are most frequent in those calm regions where apparently there are no active currents to meet each other, and they are least frequent where currents are in full activity.*" (This Journal, Vol. xxxiii, p. 61.)

77. Treating of whirlwinds excited by fire, the author thus expresses himself: "*The foregoing results can only be explained by a violent vortical action steadily maintained.* * * * *The ascending power of the vortical column or whirlwind, is strongly exhibited.* * * * *But the spire of a columnar vortex exhibits a penetrating and ascending power which far exceeds, both in its intensity and the extent of its action, any other ascending movement that we witness. This effect appears to be owing to the spiral motion of the column which presses onward in the direction of its axis, till it reaches a limit of elevation yet unknown.*" (This Journal, Vol. xxxvi, p. 56.) Would it not be as reasonable to expect the spiral of iron usually employed to open bottles, spontaneously to penetrate a cork without being actuated by the operator's hand, as that the aerial spiral, which agreeably to the description above given, constitutes a tornado, should, "*without any foreign aid*," "*or any currents to meet each other*," be endowed with the force which he has described. Admitting the storm-producing efficacy of a collision between trade winds and islands, admitting that gravitation, and rotary and orbitual force are to be substituted for all other agency, how are those causes to extend influence to his aerial isolated spiral, so as to beget the wonderful vortical force portrayed?

78. I do not deem it expedient to enter upon any discussion as to the competency of the evidence by which the gyration of storms has been considered as proved. By Mr. Espy that has been ably contested. I have given some reasons for doubting the accuracy or consistency of Mr. Redfield's representations, though I have no doubt they have always been made in perfect good faith. I have already alleged, that were gyration sufficiently proved, I should consider it as an effect of a conflux to supply an upward current at the axis. Yet the survey of the New Brunswick tornado, made on *terra firma* with the aid of a compass, by an observer so skillful and unbiassed as Professor Bache, ought to outweigh maritime observations, made in many cases under circumstances of difficulty and danger. In like manner great credit should be given to the observations collected by Professor Loomis respecting a remarkable inland storm of December, 1836. This storm commenced blowing between south and east to the westward of the Mississippi, and travelled from west or northwest to east or southeast at a rate of between thirty and forty miles

per hour. There appears to have been within the sphere of its violence an area, throughout which the barometric column stood at a minimum, and towards which the wind blew *violently* on the one side only from between east and south, and on the other only between north and west. This area extended from southwest to northeast more than two thousand miles. Its great length in proportion to its breadth seems irreconcilable with its having formed the axis of a whirlwind. The course of this storm, as above stated, was at right angles to that attributed by Redfield to storms of this kind. (Trans. of the American Philos. Society, Vol. 7.)

79. Having said so much against the whirlwind theory of storms, it may be expected that I should, on this occasion, say something respecting the opinions which I entertain of their origin. To a certain extent this will be found in my communications published in this Journal, Vol. xxxii, p. 153, Vol. xl, p. 137, also in my essay on the gales of the United States. I still believe our northeastern gales were correctly represented in the last mentioned essay as arising from an exchange of position made between the air of the Gulf of Mexico and that of the territory of the United States which lies to the northeast of that great estuary; and that the heat given out during the conversion of aqueous vapor into rain, by imparting to the atmosphere as much caloric as could be yielded by twice its weight of red hot sand, is a great instrument in the production of the phenomena; also, that the cold resulting from rarefaction is a cause of the condensation of that vapor, and of course of clouds. On this last idea, derived from Dalton, Mr. Espy has founded his ingenious theory of storms; alleging, erroneously, as I think, the buoyancy, resulting from the heat thus evolved, to be the grand cause of rain, also of tornadoes, hurricanes, and other electrical storms. In the essay above mentioned, I erred in ascribing too much to variations of density arising from changes of elevation, and twenty years' additional experience as an experimenter in electricity, has taught me to ascribe vastly more to this agent than I did formerly. To pursue this subject fully, would give this paper an undue length; yet I will subjoin a series of suggestions which in September last were submitted to the Royal Academy of Sciences at Paris. These will serve to give a general idea of the views which I entertain of the electrical causes of storms.

80. Our experiments make us familiar with two processes of electric discharge. In one of these electricity passes in the form of sparks or flashes, in the other it may be conveyed, without any perceptible evolution of light, by the alternate or successive contact of intervening bodies with the excited surfaces: as for instance by means of pith balls, pendula, or a blast of air. The former process has lately been designated by Faraday as "*disruptive*," the latter as "*convective*" discharge.

81. The disruptive process being exemplified by lightning, the magnificent apparatus of nature, by means of which this awful phenomenon is displayed, may be supposed competent to produce convective discharge upon a scale of proportionable magnitude, as exhibited in tornadoes and hurricanes.

82. As bodies oppositely electrified attract each other, *à fortiori*, attraction must always exist between any bodies sufficiently electrified for an electric discharge to take place between them. This law may be illustrated by means of an instrument called Cullbertson's electrometer. Hence the rising of the water within the track of a tornado and its subsidence on the passage of lightning, as observed by Mr. Allen, near the city of Providence, R. I.,* may be considered as resulting from the alternation of convective with disruptive discharge. By this observation of Mr. Allen, attraction is shown to have existed between an electrified stratum of air coated by clouds, and the oppositely electrified water of a subjacent river. It is reasonable to infer that attraction, originating in the same way, operating upon the denser stratum of the atmosphere in the vicinity of the earth, by counteracting gravitation may cause that rarefaction by which houses are burst or unroofed, and an upward current of tremendous force produced. We

* "The most interesting appearance was exhibited when the tornado left the shore and struck the surface of the adjacent river. Being within a few yards of this spot I had an opportunity of accurately noting the effects produced on the surface of the water." The circle formed by the tornado on the foaming water, was about three hundred feet in diameter. Within this circle the water appeared to be in commotion, like that in a huge boiling cauldron; and misty vapors, resembling steam, rapidly arose from the surface, and entering the whirling vortex, at times veiled from sight the centre of the circle, and the lower extremity of the overhanging dark cone of vapor. Twice I noticed a gleam of lightning or of electric fluid to dart through the column of vapor which served as a conductor for it to ascend from the water to the cloud. After the flash the foam of the water seemed immediately to diminish for a moment, as if the discharge of the electric fluid had served to calm the excitement on its agitated surface.

may also infer that bodies are carried aloft by the joint action of the electrical attraction, and the vertical blast which it produces.

83. The effects upon the leaves of trees noticed by me after the tornado of New Brunswick in 1835, and still more those subsequently observed by Peltier after that of Chatenaye in 1839, cannot be explained without supposing them to have been the medium of an electric discharge.*

84. When a convective discharge takes place between a stratum of air in proximity to the earth and a stratum in the region of the clouds, the greater density and pressure of the lower stratum, will cause the discharge to take place in a vertical direction.

85. Any heat imparted to air in rising from the terrestrial surface to the region of the clouds, by the condensation of aqueous vapor, being applied to the upper part of the column and rendering it as much taller as lighter, cannot speedily make its total weight less than that of the surrounding air, and must therefore be insufficient to cause any violent change, like those which constitute tornadoes or hurricanes, as argued by Mr. Espy. Moreover the process on which so much stress has been laid by this ingenious meteorologist, cannot generate rain storms during which the rain freezing as it falls, the temperature of the lower stratum is shewn to be below the freezing point of water, while that of the upper stratum, within which water condenses in the liquid form, must be above that point.

86. Were the causes assigned by Espy adequate to create a tornado or hurricane, a storm of this kind would exist incessantly in the vicinity of the equator, where in consequence of the never ceasing ascent of warm moist air from the ocean, that afflux of this fluid from neighboring regions takes place, to which the trade winds are attributed.

87. Experience has demonstrated that electricity cannot exist on one side of an electric, without its existence simultaneously on the other side. If the interior of a hollow globular electric be neutral so will the outside be; but if the interior be either positively or negatively electrified, the outside will be found in the one case positive, in the other negative.

88. The atmosphere is an electric in a hollow globular form, and as electricity is known to pervade the space within it occupi-

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† See this Journal, Vol. xxxviii, p. 80.

ed by earth, the principle in question must also pervade the space beyond that portion of the atmosphere which is sufficiently dense to insulate, or to perform the part of an electric.

89. Thus there are three enormous concentric spaces, of which the intermediate one is occupied by an electric, while the innermost one and the outer one are occupied by conductors. The two last mentioned may be considered as equivalent to two oceans of electricity, of which one may be called the celestial, the other the terrestrial electric ocean. For an adequate cause of diversity in the states of the electric oceans, it must be sufficient to refer to the vaporization and condensation of water. The power of this process to electrify, has recently been confirmed by the electrical sparks caused by the escape of high steam.

90. When either electric ocean is minus the other must be plus, and at the same time any intermediate stratum of the atmosphere enclosing a stratum of clouds, must be charged by induction if not by communication. Between the concentric strata of air, severally bounding the celestial and terrestrial ocean, there must be an electrical attraction tending to counteract gravitation and thus to influence the density and pressure of the lower stratum of the atmosphere.

91. The proximity of a stratum of clouds electrified by the celestial ocean, must cause an accumulation of electricity in any portion of the terrestrial surface immediately subjacent; and by counteracting gravitation, cause a local diminution of atmospheric pressure which is, it is well known, a precursor and demonstrably a cause of wind and rain.

92. Those enormous discharges of electricity which take place during hurricanes, may be accounted for by supposing that they result from discharges between the celestial and terrestrial electric oceans. Thunder clouds may owe their charges not only to the vaporization and condensation of water, but also to the celestial ocean previously charged by that process. Auroras may be the consequence of discharges from one part of the atmosphere to another, through the rare conductive medium which is occupied by the celestial ocean: or they may result from discharges from other planets or suns, or from any part of space however remote. Since, agreeably to Wheatstone's experiments, electricity flies with a velocity not less than that of light, distance can create no obstacle to its passage.

93. In November last, subsequently to the submission of the opinions above expressed to the Academy, I verified a conjecture of my friend Dr. J. K. Mitchell, that moist, foggy or cloudy air is not a conductor of electricity, its influence, in paralyzing the efficacy of electrical apparatus, arising from moisture deposited on adjoining solid surfaces.

94. A red hot iron cylinder, upon which evidently, no moisture could be deposited, suspended from the excited conductor of an electrical machine, was found to yield sparks within a receiver replete with aqueous vapor, arising from a capsule of boiling water.

95. Hence it appears that bodies of air, whether cloudy or clear, may be oppositely electrified, from each other or from the earth. This would explain the gyration on a horizontal axis which seems to be attendant on thunder gusts, and may account for the ascent of the southeaster and descent of the northwester in the great storm of Dec. 1836, described by Prof. Loomis.

96. Such gyration may be a form of convective discharge, in which electrical reaction is assisted by calorific circulation and the evolution of latent heat, agreeably to Dalton and Espy.

97. Squalls may be the consequence of electrical reaction between the terrestrial surface and oppositely excited masses of air, and the intermixture of masses so excited, in obedience to the same cause, may be among the sources of rain, hail, and gusts. The specific gravity of a body of air, electrified differently from the surrounding medium, may be lessened by what is called electric repulsion; the particles inevitably moving a greater distance from each other, as similarly electrified pith balls are known to do.

98. Hence a cause of rarefaction, buoyancy, and consequent upward motion, in a column of electrified air, more competent than that suggested by Espy.

99. Should it be verified that a gyration from right to left takes place, during convective discharges of electricity in hurricanes, it may be referrible to the disposition which a positive electrical discharge from the earth to the sky would have to gyrate in that direction.

ART. XII.—*Notice of two New Fossil Mammals from Brunswick Canal, Georgia; with observations on some of the fossil quadrupeds of the United States;* by R. HARLAN, M. D.

UNDER the head MEGATHERIDÆ, in the Penny Cyclopædia, Vol. 15, there is an exceedingly interesting description of the fossil animals included under this family, by Professor Owen of London. This distinguished naturalist admits five genera, viz. Megatherium, Megalonyx, Glossotherium, Mylodon and Scelidotherium; to which might be now added the "Orycterotherium" recently described by me in the Transactions of the American Philosophical Society. In this paper Mr. O. has constructed a new genus under the name of "Mylodon," from my description of the *Megalonyx laqueatus*, (vid. Med. and Phys. Researches,) together with an inferior jaw of another species obtained by Dr. Darwin, in South America; the former he names *Mylodon Harlani*, the latter *Mylodon Darwinii*. We have no objections to the construction of a new genus of the *M. laqueatus*, although we think there are scarcely sufficient data for the change under our existing knowledge of the remains of this extinct animal;—as no new light has been added to its structure since the description of the animal in the Medical and Physical Researches, 1835; from which we extract the following remarks:—"It possesses peculiarities of organic structure which certainly entitle it to the rank of a distinct species; indeed a minute examination of the tooth and knee-joint, render it not improbable, that if the whole frame should hereafter be discovered, it may even claim a *generic* distinction; in which case, either *Aulaxodon* or *Pleurodon* would not be an inappropriate term; referring to the ribbed or fluted form of the mesial aspect of the tooth." p. 330.

Mr. Owen has also made this extract from my paper, when making the new genus, and without adopting my generic name, which is very applicable,—changes the name altogether to *Mylodon Harlani*. The Greek μύλαι, *dentes molares*, conveys no distinctive character whatever as applied to this animal; the English of *Mylodon* is "molar teeth, tooth," and is equally applicable to any fossil mammal with which we are acquainted. *Pleurodon*, on the contrary, would apply to this and to all of the species described under the name of *Megalonyx Jeffersonii, M.*

laqueatus, *Mylodon Darwinii*, and to which might be now also added *Orycterotherium Missouriensis*. In fine, *Pleurodon* would characterize a group of genera, but *Mylodon* affords no character whatever.

Prof. Owen has recently read a memoir before the Geological Society of London, on the fossil bones contained in Mr. Kock's collection now exhibiting in London, and during last autumn in Philadelphia. Mr. O. after a minute examination of the numerous portions of the mastodons in this collection, of every age and size and of both sexes, many with the tusks of the inferior jaw in various stages of development; and on the existence of which the late Dr. Godman attempted to construct a new genus under the name of "*Tetracaulodon*"—arrives at the conclusion, that all these mastodon crania belong to one species, and that the genus "Tetracaulodon" is without foundation. A conclusion at which we arrived immediately, so soon as the name was published; our opinion was made public at the time, and again republished in the Medical and Physical Researches, p. 257. Copies of this notice were sent to scientific persons abroad, to editors of journals, &c., and Mr. Owen possessed a copy. The notice was also republished in Jameson's Edinburgh Journal. The genus "*Tetracaulodon*," has long since been consigned to the "tomb of the Capulets." The subject, in fine, is one upon which no two naturalists could contend in opinion. If a difference of opinion had existed, the decision of Prof. Owen, with such a mass of material on which to found his judgment, with the naturalists of Europe, will admit of no appeal.

In the Transactions of the American Philosophical Society for 1831, I published a notice of "Ichthyosaurian Remains discovered in the State of Missouri." This essay was republished in the "Medical and Physical Researches," 1835, p. 344. Subsequently in 1839, January 9th, I read a memoir upon the same subject before the London Geological Society, and proposed to change the name of this animal to "*Batrachosaurus Missouriensis*."

I was shown by Professor Goldfuss of the University of Bonn, in Oct. 1839, a principal portion of the skeleton of a fossil animal of this kind, brought from Missouri by Maximilian Prince de Wied.

With these preliminary observations I proceed to offer a brief description of a fossil Sus and a fossil Chelonia, recently obtained from Georgia. I am indebted to my intelligent friend and collaborator, J. Hamilton Couper, Esq. of Georgia, for two boxes of fossil bones, collected with much care and labor, during the excavations made in the construction of the Brunswick Canal, Georgia. The bones were principally obtained from a post-pliocene formation—the Cetacea and Chelonia were probably from the greensand. The collection consists of the remains of the following genera, viz. Megatherium, beautifully preserved specimens of the teeth and lower jaw; Mastodon, Elephant, Hippopotamus, Bos, Sus, Chelonia, and Whale. These valuable specimens are destined by the liberal donor for the cabinet of the Academy of Natural Sciences of Philadelphia. The cases also contained specimens of soil and fossil shells, mostly of recent species.

Specimens of fossil Sus have rarely been discovered; the few detached relics of this nature are derived from turfs and superficial soils. Baron Cuvier remarks, "I have never known these remains accompanying elephants." Indications of the existence of a fossil Sus I discovered several years since, in a collection of fossils obtained by Mr. Nuttall, in Newbern, North Carolina, in the newest tertiary, post-pliocene,—these were the teeth of a Sus, occurring along with mastodon, elephant, elk, deer, horse, seal, cetacea, tortoise, shark, skate, snake and fish,—all congregated together as if in the mouth of some great antediluvian estuary, and commingled with fossil shells, many of which are of existing species.

I have recently examined and taken casts of the tooth of the *Mastodon longirostris*, found in the miocene of Maryland; hitherto found only on the continent of Europe, in equivalent strata.

Sus *Americana.**

The remnant consists of the left ramus of the lower jaw, completely petrified, and impregnated with iron; containing three molar teeth, a portion of a fourth, and a socket for the anterior molar, making five on each side of each jaw, besides large tusks and incisors in the perfect jaws. The jaw has been fractured anteriorly behind the tusks, and posteriorly, immediately at the origin of the coronoid process; the foramen for the nerves and vessels through the body of the bone is very large. The following are the dimensions of the fragment of jaw.

Total length of the fragment, - - - - -	9¼ inches.
" height of do. at alveoles and base, - -	3⅜ "
" breadth of same, - - - - -	1⅝ "
Length of last molar, - - - - - -	1⅞ "
Breadth of do. - - - - - - - -	0⅞ "
Length of alveolar processes, - - - - -	6 "

The drawing (Plate III, Fig. 1) representing the exterior or dermal aspect, reduced size, obviates the necessity of more minute detail.

The crowns of the molars are so worn by detrition as to have destroyed their specific characters—the animal appears to have died at a very advanced age. In size, the animal probably surpassed the largest of our common hogs. In form of the jaw, general appearance, and number of the teeth, this fragment bears a close analogy with the same part in the *Sus babirussa*, Buff., or *babyroussa*,—which species of hog does not exist in the American continent. The structure and composition of the molars are similar, but the Babyroussa was a much smaller animal. Vide Plate III, Fig. 1.

Chelonia *Couperi.**

The right *os femoris* of a Chelonian or marine tortoise, pretty well preserved, and well characterized as a nondescript species, came to my hands, along with the others, but without a number or label attached, as in most of the others. It is completely petrified, heavy, and impregnated with iron. It bears comparison with figures 33 and 34, plate 12, of a recent Chelonia, Cuvier, Ossem. Foss., edit. 1824; and with figures 11 and 19, plate 15, for a fossil specimen. In one remarkable respect, this thigh bone differs from the same part of all recent or fossil specimens, viz. on the exterior and anterior aspect of the shaft, precisely where in other species the bone is smallest, it is here enlarged by a strongly marked scabrous protuberance or exostosis, for the attachments of powerful muscles, *vide* Plate III, Fig. 2, (*a*): so that if this species was not larger than those at present existing, it was probably proportionally stronger. The trochanter has been broken off. Total length, 13 inches. Circumference at the middle of the shaft, 9 inches. A portion of the shield of a Chelonian occurred along with this bone.

Philadelphia, May 15, 1842.

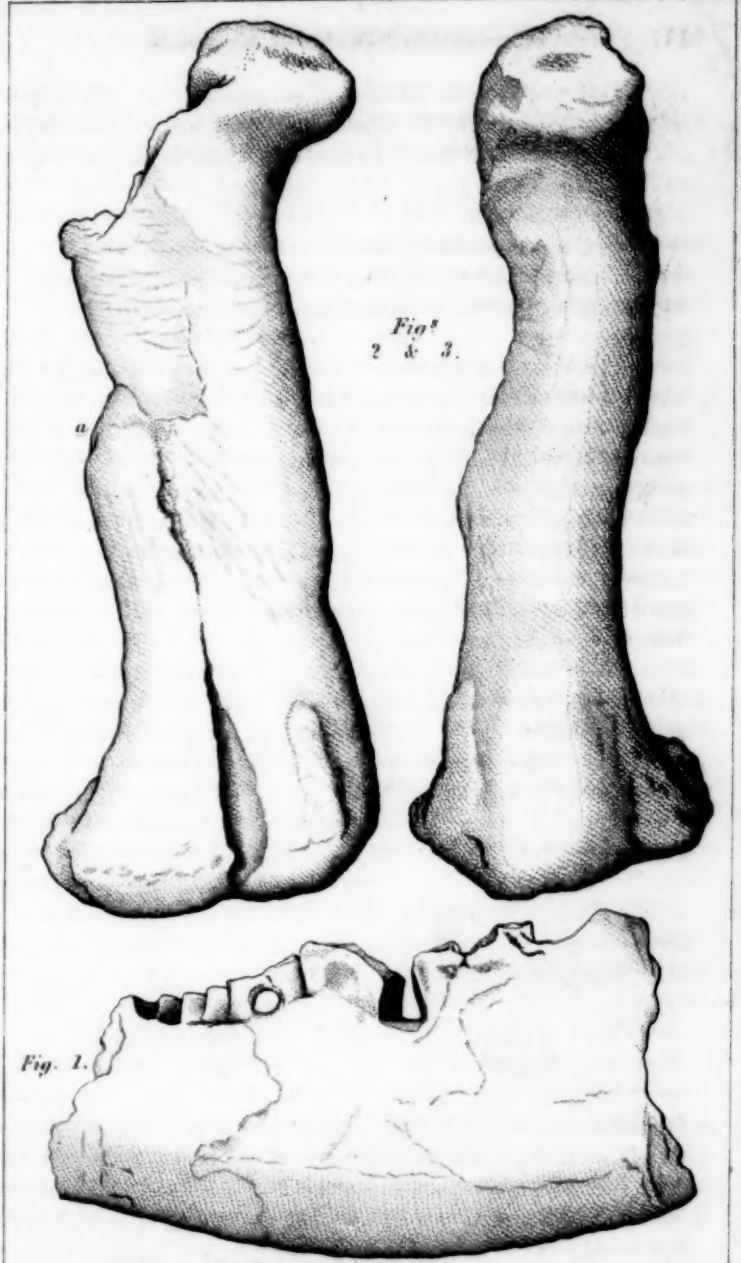


Fig.1 Sus Americana. *Harlan fragment of the left ramus of lower jaw, dermal aspect.*
Figs 2 &3 Chelonia Couperi *Harlan right os femoris.* *a scabrous protuberance.*

ART. XIII.—*Description of a New Species of Thracia;* by C. B. ADAMS, Prof. Chem. and Nat. Hist. Middlebury College.

THRACIA INEQUALIS.

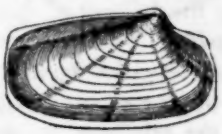
T. testâ fragili, per-inequilaterali, per-inequivalvi, irregulariter striatâ, posticè truncatâ; valvâ sinistrâ subplanulatâ; alterâ per-convexâ; callo nymphali cochleariformi, anterius elongato; ossiculo lunato, semicirculari.

Shell white, very thin, before broadly and behind narrowly truncate, very inequilateral and inequivalve, much deflected to the left anteriorly; with the striæ of growth unequal, numerous and crowded at the extremities, where, under a magnifier, the surface appears shagreened by minute wrinkles of the striæ; *epidermis* very thin, brownish, thicker at the extremities; *left valve* nearly flat, with five obtuse angles radiating from the beak; *right valve* much larger and very convex, emarginate in the whole of the posterior truncation, with a groove and elevated umbonial angle defining the areolar region, its inferior margin sinuous; *beaks* small, pointed, lamelliform, the right one moderately excavated for the reception of the other; *nymphæal callosities* spoon-shaped, very much produced forwards and inwards; *ossiculum* semicircular and lunate, with an impression on the centre of each side, but much deeper on one side, situated between the spoon-shaped apophyses and the dorsal margin.

Dimensions.—Length 1.2 inch.; height .75 inch; width .45 inch; length of ossiculum .1 inch.*

Cabinet of Middlebury College.

Habitat, Gulf of Mexico.



Remarks.—A single specimen of this interesting species was presented to the cabinet of this college by the Rev. Wm. T. Hamilton, of Mobile, Ala. It is remarkable for the disparity of the valves, the irregularity of its form, and the sharp lamelliform beaks.

* The ossiculum is enlarged about 2½ linear diameters.

Art. XIV.—*Third Annual Meeting of the Association of American Geologists and Naturalists.**

Monday, April 25th, 1842, 9 o'clock, A. M.—Association met at Boston, pursuant to adjournment of last meeting.

Dr. Morton (the chairman) not having arrived, *Prof. Locke* was called to the chair. *Dr. C. T. Jackson*, secretary. *Mr. Josiah D. Whitney* and *Mr. Moses B. Williams* were appointed assistant secretaries.

Letters were then read by the secretary from *Messrs. W. W. Mather, Robert Gilmore, H. H. Hayden, Baron Lederer, Francis Markoe, Jr., R. Harlan.* An extract from a letter received from *Dr. Douglas Houghton*, was read by *Prof. Beck.* It was then

Resolved, That all those gentlemen, whether of this or any other country, who are interested in geology and the allied branches of science, and who may be present on this occasion, be invited to unite with the Association in its deliberations.

A letter being read by the secretary from *Prof. Silliman*, stating his readiness to comply with the wishes of the Association, either to deliver his address before the Association alone or before the public:—It was

Resolved, That the address of Prof. Silliman be delivered to the Association in presence of the public.

Resolved, That the local committee be authorized to make all necessary arrangements for the accommodation of the audience during the delivery of this address.

Resolved, That any gentleman requesting permission to read a paper, on condition that it be returned to him without an abstract of its contents having been entered on the minutes, may have the privilege, on merely allowing its title to be recorded.

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* As a rule of the Association excludes mere oral remarks from the records on account of the difficulty of reporting them correctly, but sanctions the subsequent communication of them by their authors, and as these minutes were thus furnished by some gentlemen and not by others, this will account for the very disproportionate space occupied by the remarks of different individuals, as published in the annexed abstract of the proceedings. Many valuable observations have thus been lost which there is much occasion to regret, and particularly those of Mr. Lyell, of which no minutes were communicated, although the Association listened to him with much satisfaction during the several periods when he favored them with his views.

Provided only, that in all cases where the paper is to be withdrawn, as above, there shall be no discussion on the subject.

The Association then adjourned until 3½ o'clock, P. M.

Monday, April 25th, 3½ o'clock, P.M.—*Prof. Locke* in the chair.

Prof. Locke exhibited sections of the rocks of the lead regions of the Upper Mississippi, with remarks on the geology of the west.

Prof. L. proceeded to state as follows:—I present to-day some geological sections of the lead region of the Upper Mississippi. These were made by myself during the survey of the Mineral Lands ordered by Congress, and by Dr. Owen and myself with numerous assistants in 1839. A detailed report of that survey was made to the Department of the Land Office early in 1840, but owing to some mismanagement at Washington, it was published without the illustrations, which were numerous, and so connected with the text that the document became nearly unintelligible without them. As this paper, imperfect as it is, has been seen by few of our geologists, and as the sections before us are chiefly in connection with what I have denominated the cliff limestone of the west, I will ask leave to read from my printed report some remarks upon that rock. This I do more especially as it appears not to be known or recollected that I have a claim to the discovery that the metalliferous rock of the Mississippi is identical with the cliff limestone of Ohio, and that the same rock wherever it has been found is more or less metalliferous. [Here was read part of the report of Prof. L. to Dr. Owen, referred to as published in Document 239, 26th Congress, United States.—The following sections were also exhibited and explained.]

"I. A section from the heights of Little Mahoqueta through Dubuque Mines to Sinsinawa Mound, fifteen miles. This section exhibited,

1. The cliff limestone, containing in its middle and lower portions the lead veins.
2. The blue limestone (Trenton limestone).
3. Presumptively, the lower magnesian underlying the blue.

"II. A section at Prairie du Chien exhibiting the following rocks, descending series:

1.	Soil and cliff limestone,	60 feet.
2.	Blue fossiliferous limestone,	115 "
3.	Buff colored limestone,	20 "
4.	Soft saccharoid sandstone,	40 "
5.	A portion covered by soil,	40 "
6.	Lower magnesian limestone resembling the cliff lithologically, but is nearly destitute of fossils,	190 "
7.	Saccharoid sandstone,	30 "
	This last is exposed only at low water.	
	Total,	495 feet.

"III. A section from Blue Mounds to Wiskonsin River, exhibiting the following descending series of rocks:

1.	Beds of siliceous chert, containing the fossils of the cliff and forming the peaks of the mounds, - -	410 feet.
2.	The cliff limestone, containing in its lower portion lead ore, - - - - - - - - - - -	169 "
3.	The blue fossiliferous limestone, very thin, and in some places wanting, - - - - - - - -	00 "
4.	Saccharoid sandstone, - - - - - - -	40 "
5.	Alternations of saccharoid sandstone and lower magnesian limestone, - - - - - - - -	188 "
6.	Sandstone, - - - - - - - - -	3 "
7.	Lower magnesian, - - - - - - -	190 "
	Total, - - - - - - - - - -	1000 feet.

By lower magnesian limestone is not meant the magnesian limestone of Europe. The name was given by Dr. Owen in contradistinction to the cliff limestone, (which is the upper magnesian,) both containing magnesia. What has been denominated by me the cliff limestone,—a name adopted by Dr. Owen,—is properly divided into three portions, which other geologists may consider three distinct formations.

The following is Dr. Owen's subdivision of the cliff series: p. 24, Document 239, 26th Congress.

"*Upper beds.*—More regularly stratified, and less frequently vertically fissured than the middle and lower. Also, more rich in siliceous fossils, containing layers of chert, and indeed passing wholly into masses of flinty rocks, containing also good iron ore, and much crystallized carbonate of lime; but lead rarely, and in unprofitable quantities.

"*Middle beds.*—Aspect more arenaceous, though it contains but a small per centage of sand. Cherty masses are rare. Stratification imperfect, with numerous vertical fissures. Rich in ores of lead and zinc, associated with iron in small quantities.

"*Lower beds.*—Also of arenaceous appearance; rather more distinctly stratified than the middle beds, and imbedding more frequently than these siliceous cherty masses. They contain the same ores as the middle beds, with the addition of copper ore and sulphuret of zinc."

These several beds are distinguished by their fossils. The several fossils enumerated by Dr. Owen are:

"*Upper beds.—Terebratulæ*, several species of *Catenapora*, *Calamipora*, *Columnaria tubipora*, *Aulopora*, *Sarcissula*, *Astrea*, *Cyathophylla*, *Caryophylla* and *Orthocerites*.

"*Middle and lower beds.—Coscinipora* (*sulcata*? Gr.), the only coralline, a *Cirrus* resembling *perspectious; Ampularia*, in perfect impressions of a long, spiral univalve, resembling the genus *Vivipara*. It seems by the above, that there was no absolute zoological distinction between the middle and lower beds."

Permit me here to add as a claim of the western geologists, rather strangely overlooked by some *eastern* writers on *western* geology,—that besides these all the other western rocks yet made known, have been described by western geologists. Especially the bed of mountain or carboniferous limestone, superimposed on the cliff at the upper rapids of Mississippi, underlying the great Illinois coal basin, cropping out at St. Louis, and forming the bluffs at and above Alton, Illinois, with its characteristic fossil, the *Archimedes* of Le Seuer, was well known to Messrs. Troost, Owen and myself. The same rock occurs within the limits of the survey of the Professors Rogers, who belong, in part at least, to the western corps. In 1839, I had the pleasure of comparing notes with Prof. James Rogers, on the characters of this very rock as it occurs in Indiana and Illinois on the one part, and in Western Virginia on the other. I hope yet more specifically to settle the claims of the various *laborers* in our western geology. At the same time I would observe that it is impossible for an eastern geologist, without visiting the west, or even by a post-haste journey over the trans-Appalachian world, to write upon its geology without committing errors injurious to his own reputation, the publication of which, he would of course, gladly recall.

Remarks were offered and facts stated on the above subject by *Dr. King*, *Mr. Haldeman*, *Mr. Teschemacher*, *Prof. Henry D. Rogers*, *Dr. C. T. Jackson*, *Prof. Vanuxem*, *Prof. Hitchcock*, *Prof. Beck*, and *Dr. Dana*.

Mr. Haldeman laid on the table, at the request of Dr. Morton, some copies of a work on cretaceous fossils, bringing our knowledge of this subject near the present day, most of these being from the researches of Prof. Nicollet.

A letter was read from *Prof. Park* of Philadelphia, regretting his inability to attend the present meeting. The Association adjourned to—

Tuesday, April 26th, 9 o'clock, A. M.—*Prof. Locke* in the chair. The committee on the constitution and by-laws was called upon for report. *Dr. Jackson* read the rules, as submitted by this committee.

*Constitution and By-Laws of the Association of American Geologists and Naturalists.**

Art. I. The Society shall be called "The Association of American Geologists and Naturalists."

* The constitution and by-laws as here printed, were in fact adopted at the session of Wednesday, but it is thought expedient to insert them here, as they embrace all the rules which were adopted on Tuesday and thus to avoid repetition.

ART. II. The objects of this Association are the advancement of geology and the collateral branches of natural science, and the promotion of intercourse between those who cultivate them.

ART. III. All those persons whose names have already been enrolled in the published proceedings of the Association, and those who have been invited to attend the meetings, shall be considered members on signing the Constitution and By-Laws.

ART. IV. Members of societies having in view the same objects as this Association and publishing transactions, shall be considered members upon subscribing to the Constitution and By-Laws.

ART. V. Persons not embraced in the above provisions may become members of the Association, upon nomination by the standing committee, and by concurrence of two thirds of the members present.

ART. VI. The officers of the Association shall be a chairman, a secretary, and a treasurer, who shall be elected at each annual meeting.

ART. VII. The secretary may appoint two assistant secretaries to aid him in the discharge of his duties.

ART. VIII. The Association shall meet annually for one week—the time and place of each meeting being determined by a vote of the Association at the previous meeting, and the arrangements for it shall be entrusted to the officers and the local committee.

ART. IX. The standing committee shall consist of the chairman, secretary, and treasurer, with nine other members present who have attended the previous meetings.

ART. X. It shall be the duty of the standing committee to nominate members for admission, and to manage the affairs of the Association.

ART. XI. The local committee shall be appointed by the standing committee from among members residing at or near the place of meeting, and it shall be the duty of said committee to make arrangements for the meeting.

ART. XII. The expenses of each meeting shall be defrayed by an equal assessment on the members present.

ART. XIII. All communications to the Association shall be presented in writing, and upon them discussions may take place which shall not be reported, but the facts presented in such discussions may be reduced to writing by the persons communicating them, and they may then be handed in at a subsequent session, when they may be entered on the records.

ART. XIV. If communications are made, and notice is given that they are to be withdrawn for publication elsewhere, they may be read, but no discussion shall take place on them.

ART. XV. No article of this Constitution shall be altered or amended without the concurrence of three fourths of the members present, nor

unless notice of the proposed amendment or alteration shall have been given at the preceding annual meeting.

Dr. Morton having arrived, took the chair as president of the meeting.

Resolved, That *Prof. Locke*, *Dr. Jackson*, and *Prof. Hitchcock*, be appointed a committee to prepare business for the Association.

Prof. Hitchcock then read a paper "on the Phenomena of Drift in this country," which was illustrated by numerous drawings, and a map of the United States, on which were drawn lines representing the course of the striæ, and lines of dispersion of bowlders. In the course of his paper Prof. H. called on *Mr. Gray* to describe a remarkable moraine in Andover, Mass. Mr. Gray stated this moraine to be one mile long and fifteen or twenty feet in height. At the close of this paper, an animated and extended discussion arose on the subject of drift.

Dr. Jackson objected to the views of Prof. Hitchcock, as published in a recent report on the Geology of Massachusetts, but having had an opportunity, since those views were published, of conversing freely with Prof. H. he found but little real difference in their present opinions. He would, however, by no means consider that we could yet form an unobjectionable theory on the subject of drift, polished grooves, and the transportation of erratic blocks of stone. If we admit several different causes, how remarkable would it be should they be found to have acted in nearly the same direction! Yet we cannot agree upon any known cause, as sufficient to explain all the facts. This country exhibits no proofs of the glacial theory as taught by Agassiz, but on the contrary the general bearing of the facts is against that theory; for we observe nowhere in this country a general radiation of detritus from the principal mountain ranges, although, as in Rhode Island, there is a divergence from the point whence the bowlders were derived. This divergence is however merely a spreading of fifteen miles for forty in extent, and it is in the usual general direction of North American drift to the southward; none of the bowlders having been drifted to the north of their parent bed.

Mr. Lyell offered some remarks on the subject of the distribution of bowlders and of the furrows in the rocks, citing the result of many observations in Europe.

Mr. Redfield had from his limited observations been led to infer that the drift of the region near New York was the joint result of glacial and aqueous action, and was mainly deposited during a period of increasing submergence. Mr. Redfield also alluded to the agreement of the striæ of the polished rocks, and of the transported bowlders and drift, with the known course of the existing polar currents of the ocean, in the northern hemisphere; and suggested that this system of currents, being essentially the same in both hemispheres and having its cause in the dynamics of the solar system, must have operated through all time, and over extensive regions, but varying in locality and direction with the changes of outline and relative levels of seas and continents, during successive geological periods.

Some discussion then ensued on the question whether the mounds of the western United States were the result of natural diluvial causes or the work of the Indians.

Mr. Lyell cited an instance where the inhabitants of Scandinavia, had taken advantage of a long and very high natural ridge, to form three separate mounds, which they afterwards considered as the burial places of their fabulous deities.

Prof. Silliman remarked with respect to the genuineness of mounds, as works of man, in contradistinction from those natural piles, that have been cut out of the strata of clay, sand, gravel, loam, &c., and rounded and shaped by water so as to resemble works of art—that artificial mounds (found in many and distant countries, both on the eastern and western continent) appear to have been characteristic of a particular state of society advanced beyond barbarism, but not yet sufficiently civilized for the construction of massy sepulchres of solid stone, sarcophagi, pyramids and temples. He appealed to those numerous mounds which form a most impressive feature of the scenery on Salisbury plain in Wiltshire, in the southwest of England. Prof. S. had counted seventy of these mounds in one view, while sitting upon his horse upon the top of a low one, and from the same place Dr. Stukeley says that he enumerated one hundred and twenty eight. These mounds are rarely less than thirty feet in diameter; they are generally surrounded by a broad ditch, enclosed by a circular or oblong parapet or embankment. Near Overton in the west of England, Prof. S. ascended one which was one hundred and seventy feet high and whose base covered about an acre of ground, its form being that of the lower segment of a cone.

The void, from which the earth was taken, remains to this day, and is as evidently an artificial excavation, to form an artificial hill, as any modern fortification with its ditch and glacis. There remains not the smallest doubt, that these mounds were erected both as sepulchres, for distinguished individuals, and as monuments of victories. The remains of the dead have been often found in them, either skeletons or ashes—with heads of spears, swords, bones of horses, dogs and other domestic animals, sometimes beads, trinkets, and female ornaments, articles dear to the departed while living and which were believed to be important to them in another world.

Prof. H. D. Rogers remarked in relation to Mr. Lyell's opinion of the gradual rising of the North American terraces, that if such was the case, fossil shells or marine sedimentary accumulations, should be found at all elevations on the mountain slopes, which are covered with marks of diluvial action, at every height. It has not been shown by examination that such is the case, hence he infers that the cause which produced the elevation was paroxysmal in its operation and effects, and not secular, or gradual, and uninterrupted. In order to explain the theory of diluvial phenomena, he would suppose with Mr. Lyell, and others, that the region around the north pole was capped with ice, in immense masses, and that by a sudden outburst of volcanic action, this was dispersed, and sent in a quaquaversal direction towards the equator. But if we suppose that this was accompanied by an earthquake, rocking, or wave-like motion, of the bed of the ocean, the whole mass of torn-up strata would be shoved violently from N. to S., and at every heaving of the earth, a mass of water would be thrown forward, like the rolling in of a tremendous surf. Mr. Couthouy's observations among the coral islands, would go to strengthen this theory, while the rocking movement of the earth's surface during an earthquake, had been long ago admitted.

Mr. Couthouy remarked in relation to the paroxysmal rise of the land at intervals, that on one island which he had visited, which was about two hundred feet in elevation; about one half way from the base to the summit, the face of the cliff was deeply sea-worn and indented; as its present base would appear should it be at this moment raised above the ocean level, when it would present similar marks of powerful and long continued action of water, at the part which was before on a line with the sea. In

regard to the bowl-shaped cavities, encircled on all sides by regular hills, he suggested that they might have been worn by the rotary motion of icebergs; this rotary, or semi-rotary motion of the icebergs, he had noticed both in those which were and were not stranded. They become gradually worn away on one side by the action of the water, when they turn over with a displacement of the sea, and violent upheaving of the mud and sand, rendering the water turbid to a great distance.

The discussion was continued by *Mr. Lyell* and *Mr. Couthouy*, on the probable agency of icebergs in diluvial phenomena, and especially in regard to the water-worn cavities or pot holes.

Dr. C. T. Jackson described the pot holes which occur in Orange, near Canaan, in the elevated land between the Connecticut and Merrimack rivers in N. Hampshire. They are worn in a hard granite-gneiss, in a line following the general N. and S. direction of the diluvial or drift current. One which had been cleared of the round smooth stones which formerly filled it, and which is known to the inhabitants as "the well," is eleven feet deep, four and a quarter feet wide at the top, and two feet at the bottom. These pot holes could not be referred to the action of any existing current of water, as they are on the water-shed line, between the two rivers, and more than one thousand feet above the sea level.

Mr. John H. Blake was requested to prepare a paper on the tertiary and drift of the Andes.

Prof. H. D. Rogers remarked in relation to stranded icebergs, that coming from the north, loaded with bowlders, and stranded far above the sea level, they would, while melting, produce all the phenomena of the glaciers of the Alps.

Mr. Couthouy was requested to draw up a paper, embracing the facts which he had collected in regard to icebergs, to lay before the Association. Mr. C. having, in accordance with this request, prepared the following summary of his observations and the remarks he had made concerning them, at the present session, it is here inserted.

Mr. C. premised that in order to give the remarks he was about to submit, their full weight, it might be proper for him to state, that he had no preconceived opinion—no hypothesis of his own upon this question, to sustain. His intention was simply to offer a few facts which had fallen under his personal observation, with the inferences to which they

had led his own mind, leaving abler judges to decide upon the value of such facts and the correctness of the inferences. He remarked that the opportunity of witnessing the actual operation of the huge bodies of drifting ice, known as Bergs or Islands, was of so rare occurrence that its true character appeared to him not clearly understood, and consequently geologists were liable to overlook or err in judgement upon some important points in the dynamics of aqueo-glacial agency. Mr. C. then proceeded to a statement of the geographical position of a number of icebergs, as determined by reference to his journals. The first noted was observed on the 28th of May, 1822, during a passage from Havana to Rotterdam, and was in 42° 10′ N. lat., 44° 50′ West from Greenwich. Its size must have been very considerable, as it was visible from the deck of a vessel of two hundred tons, for eighteen miles. Numerous small streams of water were pouring down its sides, and a boat was sent with a view to obtain a supply, but on approaching it, the swell, notwithstanding its being quite calm, was found to dash against its face with such force, and the lower portions were so worn and ragged, as to render it inaccessible. Although the weather was so serene, and the sea so tranquil, yet the berg was constantly turning slowly round as the swell struck its many promontoriform projections. It appeared to have lost little of its primal magnitude, the summits retaining a conical or rounded form, instead of being worn like others he had seen, into sharp pinnacles and acicular ridges by the action of the atmosphere and rain.

The next observed by Mr. C., was on the return passage in September of the same year. It was aground on the eastern edge of the great Bank of Newfoundland, in 43° 18′ N. lat., 48° 30′ W. long. Sounding three miles inside of it, the depth was found to be one hundred and five fathoms, and as the water deepens rapidly toward the edge of the bank, the berg must have been in at least one hundred and twenty or one hundred and thirty fathoms. There was a heavy sea running at the time, causing it to rock, and oscillate horizontally to and fro, with a heavy grinding noise distinctly audible to all on board. A fresh wind from the east was continually forcing it farther up on the bank, but in the event of a contrary gale springing up, it would doubtless have been driven off again into deep water to pursue its course to a milder clime, loaded with materials ground into its base while stranded.

Between this period and the summer of 1827, several icebergs were seen by Mr. C., but not being able at present to lay hand on his journals of that interval, he could enter into no particulars, farther than to state that as with a few exceptions, his voyages were between the United States or West Indies and Great Britain or the Mediterranean, it was probable that they were chiefly met between the 36th and 42d parallels of north

latitude. He remembered however, having encountered in November, 1825, off the entrance to the Rio de la Plata, in latitude 35° south, longitude 49° west, or thereabouts, a number of icebergs, some of which were of large magnitude; a reference to the chart would, he observed, show to what a vast distance from their birth-place these floating masses had been driven by wind and current.

In the month of August, 1827, while crossing the Grand Banks, in latitude 46° 30′ north, longitude 48° west, Mr. C. passed within less than a mile of a large berg which was stranded in between eighty and ninety fathoms water. The wind was light, but a heavy swell was running from the westward, and the huge pile could be distinctly seen to rock and shake violently as it ground heavily down into its bed with every surge. Owing to its longest diameter facing the swell, the mass had an oscillatory or semi-rotary back and forward motion upon its vertical axis, according as the sea broke upon one or the other extremity, which it did with so much force at times as to turn the berg apparently full half round; in this situation it would remain till another heavy surge striking the opposite end would force it back and round in the other direction. The vessel was sufficiently near for Mr. C. to perceive distinctly, large fragments of rock and quantities of earthy matter imbedded in the sides of the iceberg, and to see from the fore yard, that the water for at least a quarter of a mile round it, was full of mud, stirred up from the bottom by the violent rolling and crushing of the mass. This movement was accompanied by a harsh grating noise, with occasional cracking reports, resembling those produced by blasting rocks, which might have been heard ten or twelve miles. The height of this berg was estimated by Mr. C., at from fifty to seventy feet, and its length at four hundred yards. While examining it through the glass, it was observed to incline suddenly more than usual, and in the next moment, with a crash and roar that were truly fearful, and amid a whirlwind of spray and foam, the whole enormous pile rolled over on its side, tearing up with it, no doubt, large quantities of matter from the bottom, and loading the sea with mud and sand for more than a mile in all directions from its bed. On the 27th of April, 1829, Mr. C. passed, in latitude 36° 10′ north, longitude 39° west, near the middle of the Gulf Stream, which there set in an east-south-easterly direction, an iceberg estimated to be a quarter of a mile long, and from eighty to one hundred feet high. It was much wasted in its upper portion, which was worn and broken into the most fanciful shapes, forming resemblances of minarets, spires, pyramids and castellated ridges, whose character was momentarily changing by reason of the berg moving backward and forward horizontally with great quickness. A strong breeze, and numerous smaller fragments of ice floating in its vicinity, prevented a very near approach,

but on one side, a large earthy colored patch was seen, having numerous blacker spots, which Mr. C. had no doubt were bowlders, scattered over it. Some of these presented a surface of two or three hundred square feet.

In 1831, on a passage from Boston to Mobile, at daylight of 17th August, in latitude 36° 20′ north, longitude 67° 45′ west, upon the southern edge of the Gulf Stream, Mr. C. fell in with several small bergs in such proximity to each other, as to leave little doubt of their being fragments of a large one, which weakened by the high temperature of the surrounding water, had fallen asunder during a strong gale which for several days previous had prevailed from the southeast. The natural tendency of this would be to force the berg into the warm northeast current of the stream, where, already much worn by its prior sojourn there while crossing from the north, its separation soon took place. The strong northwest wind immediately following the southeast gale, probably drove the fragments out of the Gulf again, to where they were seen in the eddy current, which Mr. C. found to set in that place southwest, at the rate of half a mile per hour. And here, said he, a suggestion of much geological interest presented itself to his mind. Supposing an iceberg of the present day to break loose from the northern polar regions, loaded with blocks of stone and gravel, and drifting southward, to strand upon the Banks of Newfoundland, or George's bank near our own shores, and there remain for a considerable period grinding themselves upon the ocean's bed, thereby incorporating into their mass, portions of it, such as shells, gravel, sand, clay or stones. Owing to the unequal action of the weather upon its surface, and water on its submerged portion, it might as has been shown, turn partially or even entirely over, thus placing the newly gathered matter above water, and if the old were at the bottom previously to the overturn, mixing together the rocks from both localities. Loaded with this additional material, it might float off and resume its southerly course, till accidentally forced into the Gulf Stream and carried eastward at the rate of 24′ a day, (the mean velocity of the Stream in the meridian referred to,) till it was melted away. To affect this dissolution would require three or four months, during which time, the berg would be carried six or seven hundred miles in a direction nearly at right angles with its primary drift, depositing a greater or less quantity of transported material along its entire track. Mr. Couthouy remarked that the instance just cited, was one of peculiar interest, from its illustrating the manner in which rocky materials imbedded in icebergs, may through the devious course of these latter, be deposited along a wide range of longitude as well as latitude. He called attention to the fact that this berg was to the southward of the Gulf Stream, and about 18° or seven hundred and fifty miles west of a

meridional line, passing through the centre of the grand Bank of Newfoundland. It was the only case within his knowledge, of an iceberg being seen so near our continent in this parallel. He shewed by reference to a chart of the Atlantic, that in all probability this one entered the Gulf Stream at least as far eastward as the 48th deg. of west longitude, and in the 42d or 43d parallel of north latitude. It was his opinion that this occurred in the spring of the year, when the prevalent strong northeast winds would drive it southerly across the stream with nearly as much rapidity as the latter would carry it forward in an easterly direction. To exemplify this, said Mr. C., we should work out the drift, and true course of this berg, precisely as a seaman would do that of a ship hove to the wind for the same length of time, and under like circumstances. Assuming then that the berg in question, had impinged upon the Gulf Stream in the latitude and longitude above given, and there encountered one of the northeast gales, so frequent, and of such long continuance on our coast in the spring;—half a mile per hour would be a moderate allowance for its set southwestward by the wind and heave of the sea. In forty days, (and it is well known that easterly gales often prevail over this part of the Atlantic during the spring months, for even a longer period;) in forty days, it would, were there no opposing agency at work, be propelled three hundred and forty miles west, and the same distance south of its point of entrance into the Gulf Stream. But as in this parallel, there is a current setting in an east by south direction, with a mean velocity of three quarters of a mile per hour, this would during the assumed period, not only counteract the wasting caused by the swell, but carry the berg three hundred and sixty-eight miles east, and one hundred and twenty miles farther south, making its true line of drift up to the close of the forty days, to be south 38° east, and the distance traversed four hundred and seventy miles. This would place it in latitude 34° 50′ north, longitude 38° 30′ west, or about across the Stream, here not far from four hundred and fifty miles wide. From this point to the locality in which the fragments were seen, its course would be about south 84° west, and the distance one thousand four hundred and seventy miles. Assuming that the eddy current and heave of the sea combined, were equal to impelling it westward at the rate of three quarters of a mile an hour, it would require about eighty days to transport it to the locality in question. But as the wind although acting upon it generally from the eastward, cannot be supposed to have done so constantly, it might be a considerably longer time in performing the voyage.

Mr. Couthouy exhibited a chart of the Atlantic, with the assumed track of the iceberg met by him, marked upon it, and pointed out that its drift westward must have been at least as great as he had there repre-

sented; since it could not, owing to the trend of the coast of Newfoundland, have entered the Gulf to the westward of the point designated, but on the contrary was likely to have done so farther eastward. Moreover, as it could by no possibility have reached the spot where he fell in with it, without having been driven across the Gulf Stream into the westerly eddy, it was obvious that unless the heave southwestward by the northeasterly wind and swell were admitted, it must have been for a much longer period in the Stream and finally emerged to the southward of it, at a point much farther south and east than he had assumed in his calculation of its course.

That a mass of ice so considerable should remain after so long a sojourn amid the warm waters of the Stream, would not, he observed, appear surprising, when the enormous magnitude of some of the masses that have been encountered by voyagers in these seas was taken into account; together with the fact that they produce by their dissolution, carry about with them, and occasion to a great distance around them, a very material decrease of temperature, both in the air and ocean, which tended to render the operation a much more gradual one than we might at the first glance imagine. From the record of a journal kept by Francis D. Mason, Esq., in June, 1810, on a passage from New York to Halifax, N. S., and published in Blunt's American Coast Pilot, edit. 1827, it appears that the water at seven miles from some icebergs, was from 12° to 15° below the average temperature where it was not affected by the presence of such bodies. One of these islands is represented as having been one hundred and fifty feet in height, and a mile in extent. It was easy to conceive of masses like this, resisting the action of air and water for a much longer period than would suffice to place the berg, whose course has just been described, so far from the point of its northern entrance into the Gulf Stream.

The last iceberg of which Mr. C. was prepared to speak from personal observation, was encountered by him on the 4th of March, 1841, in the Pacific Ocean, during a passage from the Hawaiian islands to Boston. It was of great magnitude. Its height could not have been less than two hundred and eighty or three hundred feet, and its longest diameter two thirds of a mile. The ship sailing at the rate of seven miles an hour, was two hours and three quarters in coming up with it after it was first seen from the deck, when it already loomed up like a large islet. Immediately on its discovery the ship was headed directly for it, till within half a mile of the berg, at which distance it was passed. Without the aid of a glass Mr. C. distinctly saw enormous masses of rock projecting from different parts of this ice mountain, some of them apparently having a surface of at least twenty feet square. The swell, which was very heavy from the westward, washed

up the sloping sides to the height of eighty or one hundred feet, recoiling in vast sheets resembling cataracts; and where the face of the berg was perpendicular, the surf broke against it as if it had been a wall of rock, with tremendous force, and a booming roar like that of distant heavy thunder. There appeared to have been a recent overturn of the berg, inasmuch as the water for a mile's distance from it was full of fragments, some of them sufficiently large to endanger a vessel. One of the most remarkable phenomena observed by Mr. C., was the almost incredibly rapid revolution of this huge body on its vertical axis, in consequence of which, it did not present the same aspect for two minutes together. One moment it was a pyramid, the next barn-shaped, and in another a glittering pile of peaks and serrated crests, or battlements, like those of some ancient castellated citadel, was exhibited. Scarcely was there time to sketch the rudest outline of one configuration, ere it gave place to another totally dissimilar. This melting away of the various figures, could be compared to nothing better than the sudden and fanciful changes we see in turning a kaleidoscope. Mr. Couthouy here exhibited to the Association a series of sketches taken at the time as illustrative of the variety of form spoken of. The following statement of the temperature of the air and ocean at various distances from the berg, was given as evidence of the great extent to which they were affected by its presence, and the influence which, as before mentioned, this circumstance exerted on the retardation of the dissolution of similar masses:

	Noon.	2 P.M.	3 P.M.	3 30 P.M.	4 P.M.	4 30 P.M.	5 P.M.	5 30 P.M.
Air,	54°	53°	50°	46°	42°	37°	35°	37°
Water,	50°	50°	48°	44°	43°	36°	36°	40°
Distance of berg,	33′	19′ (visible,)	12′	8′	4½′	1′	3′	6′

When nearest the iceberg, (which was within a short half mile,) the water was at a little below 34° Fahr., and the air at 35°. After passing the island, when about two miles to leeward, a smart fall of hail was experienced, which lasted about ten minutes. By this statement it appears, that the water three miles to leeward of the island was 7° Fahr. colder than that four and a half miles to windward, and at six miles, 3° colder than at four and a half and 4° colder than at eight miles to windward, owing probably to a surface current carrying the cold water from it in the direction the wind was blowing. The latitude of this ice island was 53° 20′ S., and its longitude 104° 50′ W., making its distance from Terra del Fuégo, the nearest eastern land, one thousand four hundred and fifty miles, and one thousand from St. Peter's and Alexander's Islands, the proximate southern land from which it could have been detached. From its great magnitude, it was the opinion of Mr. C. that should this berg have been driven by the westerly

gales which prevail in that region of the Pacific during so large a portion of the year, into the current setting constantly to the northward along the whole west coast of South America, it might have floated to the verge of the tropics ere it dissolved entirely, or perhaps been stranded somewhere about the shores of the Chiloan Archipelago.

The attention of the Association was called to the fact of such large masses of rock, which were undoubtedly once at the bottom of the berg, being exposed on its face or sides. Mr. Couthouy conceived that the dissolution below the surface by the action of the water, and above it by that of the weather, being unequal in different portions of the berg, especially when it was aground, and consequently one side more constantly exposed to the sun's rays than the other; the equilibrium would be occasionally destroyed, the result of which would be an overturn, like that witnessed upon the Grand Banks, bringing to the surface portions of the mass containing rocks and earth. The U. S. ship Peacock, during her last cruise of discovery in the Antarctic Ocean, while attempting to penetrate the great barrier of ice, was seriously injured, and narrowly escaped utter destruction, from the separation and toppling down of a huge fragment of an iceberg. Had not this latter been still attached to the main body, there can be no question but that one of the violent overturns referred to, would have followed such a change in the proportions of the berg. Again, in the case of a drifting island, where from its rotary motion it is probable the waste from exposure would be nearly equal on all sides, it is evident that the side in which the rocks were imbedded, would, owing to their specific gravity being much greater than that of the ice, gradually preponderate, and either produce a sudden and violent change of axis, or slowly settle down once more, according as circumstances varied. In smooth, still water, the latter would probably occur, while the former might be expected to happen in a tempest or a heavy sea. In connection with these facts, Mr. C. submitted the following supposititious case, as one by no means of improbable actual occurrence, the first portion of which, indeed, was merely a statement of what had really taken place in the great iceberg last described. Suppose an island of ice to be detached from the great southern barrier, having its base loaded with rocks, &c., and after drifting several hundred miles northward, to experience an overturn bringing these rocks to the surface. It then floats on for a considerable distance farther, till from the equilibrium being again destroyed, the rocky portion settles down and resumes its original position. These alternations may occur several times. Driven landward by the heavy westerly swell into the continental northern current, it is at length stranded on the coast of South America, and undergoes one or more overturns, bringing up at each time an additional amount of

material. It then is forced off by a strong off-shore wind, and after drifting still farther north is stranded again, perhaps at a long distance from its first anchorage. New overturns follow, fresh materials are accumulated, but from waste, the whole mass becoming lighter, it is once more floated off, and pursuing a somewhat devious course toward the tropics, is gradually melted away. Could that part of the ocean's bed over which such an iceberg has passed be laid bare for our inspection, what would be the appearances presented? The early progress of the mass would be marked by a deposition of large angular fragments of polar rocks. Subsequent to the overturn there would be an interval with few or no traces of its path, till the rocky portion of the berg had resumed its original situation, when the deposition would be continued, and these alternations would evidently correspond to the number of overturns. The larger masses of rock would for the most part be the first to drop out, and latterly the majority of matter might consist of smaller and more rounded fragments, such as had been worn by the grinding of the ice on the beach or bottom. Prior to the last, or even the first stranding, all, or nearly all the rock and earth originally contained in it might be deposited, when the latter portion of its track would be marked by a comparatively scanty amount of material from its more recent halting places, perhaps confusedly mixed, and affording here and there some slight indications of the birth-place of the berg, in the occasional presence of a fragment of the remote Antarctic soil.

Was there aught, asked Mr. C., in the evidences of ancient aqueo-glacial action, analogous to such a mixed deposition, and irregular distribution of materials from widely separated localities, as would result from the conjectural case here presented, or the actual one of the iceberg previously cited as fallen in with on the southern margin of the Gulf Stream? Did they explain any of the obstacles and apparent anomalies presented by the aqueo-glacial theory of the drift formation? These were questions which he submitted for the decision of those whose attention had been more specially directed to this subject.

In reference to the advance and northern limits of icebergs from the Antarctic in the eastern hemisphere, Mr. C. could state nothing from his personal knowledge, farther than that they frequently occur at least as low as the thirty-fifth parallel of latitude. During his residence in New South Wales, in the summer and autumn of 1839–40, (December to March,) several ships arriving at Sydney from England, reported having fallen in with large icebergs in the vicinity of the Cape of Good Hope, at least 1800 miles from the nearest southern land; along the whole of which distance they possibly deposited material from their polar starting point.

Mr. C. stated that he would here offer a few brief remarks upon the bearing of the facts he had submitted upon the question of the results of aqueo-glacial action in past times, and especially in the effects produced upon subjacent rocks by the stranding of icebergs. It was with much diffidence that he dissented from the opinion entertained by some eminent geologists, that this circumstance had any agency in producing the parallel grooves constituting so remarkable a feature in the rocks of New England. Even assuming that in a former era the drifting masses of ice had pursued an uniformly direct course from north to south, though this might explain the general distribution of erratic blocks and bowlders, yet it appeared to him highly improbable that their grounding, and then being driven forward by the combined forces of wind and sea, could ever have produced the furrows in question. There is no reason why the oscillatory or semi-gyratory movement, should not then have followed such an accident as it does now, in which case, as at present, the tendency would be rather to obliterate all such marks, (had they previously existed,) and form a deep hollow if passing over a yielding surface, or a confused scratching and grinding down of a rocky one. It had been shown, however, that the icebergs of the present day pursue a very irregular course, and although their general progress is truly from north to south, or the reverse, yet impelled by varying winds and currents, they deviate widely both east and west of a meridional line. Did not this fact in some measure explain the difference pointed out by Prof. Hitchcock as apparently existing between the line of direction observable in the distribution of bowlders, and that of the diluvial scratches? It had been suggested, that at the period when the drift was deposited there was no Gulf Stream to affect the course of floating ice, but while this may be very true, it does not follow that there were no currents whatever. It struck him that to assume the production of our parallel grooves by the action of stranded ice, was to presuppose a state of things, a combination of circumstances amounting to a physical impossibility.

Not only must it be taken for granted that there were no currents, or at least but one from the pole to the equator, and only one perennial wind blowing in the same direction, but the floating masses must either have been of such nicely balanced proportions, and melted with such uniform regularity, and the waves must have struck them so exactly from the same quarter, as to have prevented any change of position; or they must have been in such numbers and so closely packed as to preclude any oscillatory movement.

Was it essential to the explanation of the phenomena of drift, to assume that the distribution of bowlders, and the production of our so-called diluvial scratches, were entirely the result of contemporaneous

action? Might there not have been a period when the northern portion of our hemisphere was covered with glaciers resembling those of the Alps, during which the furrows were produced by their gradual and radiolinear advance, followed by one of drifting ice, (whether borne along with a sudden rush of waters, caused by a paroxysmal elevation of land in the vicinity of the pole, or floods resulting from a gradual melting away of the mass, he would not now pause to inquire,) depositing bowlders through its course, and by the stranding and grinding of large masses into beds of sedimentary matter or drift, have occasioned the singular contortions visible in portions of the clay strata?

If it could be shown that a sudden and violent rush of waters from the polar region had taken place, sweeping over the whole northern portion of this hemisphere, bearing along with it large islands of ice, denuding the hills and filling the valleys with drift, and eventually subsiding almost as rapidly as it poured southward,—would not this induce a belief that the remarkable, large bowl-shaped cavities described in Prof. Hitchcock's able memoir on the drift of New England, as existing on Cape Cod and elsewhere, might have been formed by the stranding and grinding of large islands of ice down into the recently deposited drift? It occurred to Mr. C. at once, when these excavations were alluded to by Prof. Hitchcock, in connection with ice, that they might have originated in this manner, rather than from the deposition of matter round the melting ice, as suggested by that gentleman,—or they may have been produced by a combination of these two operations; the grinding and settling down of the stranded berg, excavating a hollow, while the earthy materials contained in it would be piled up round the sides as it dissolved. If we supposed a very large berg of the pinnacled character, to have been left aground by the subsidence of the paroxysmal flood, and divided into several smaller ones, each forming a separate crateriform bed for itself, we should then readily comprehend the production of such a group of these cavities as was described by Prof. H. Whether these suggestions were borne out by the geological features of the drift in general, was left for those to determine whose observation had been more specially directed to a study of these phenomena. Mr. Couthouy observed that he would merely repeat that in relation to the production of diluvial, or to speak more correctly, glacial furrows, he had no preconceived views of his own to support, but that when he first heard them attributed to the grating along the bottom of icebergs, he was convinced by the recollection of what he had personally witnessed of the action of ice under such circumstances at the present day, that this never would have produced such results. The parallelism and uniform direction of the striæ, appeared to him conclusive of a different agency in their formation. He felt persuaded

that no person who had once seen the actual movements of a stranded iceberg, would ever afterwards entertain for a moment the idea that such a cause would produce the furrows under consideration. He also thought it very problematical whether icebergs would by their stranding, and being irregularly pushed forward by wind and wave, produce moraines, having much if any affinity with those resulting from the slow, regular advance of the Alpine glaciers.

He offered these suggestions with no small hesitation, fully sensible how presumptuous it might seem in him to venture a difference in opinion with those eminently distinguished geologists who had addressed the Association on this topic. They were, however, such as arose naturally in his mind while reflecting on what had passed under his own observation. The facts on which they rested were before the members, and so little was really known, so few had an opportunity of witnessing this part of the aqueo-glacial agency now going forward, he felt sure that they would excuse his having trespassed on so much of their time in submitting at least these facts for their consideration.

In conclusion, Mr. Couthouy remarked, that he had in this paper used the term *aqueo-glacial* to express the nature of the action of water and ice, in connection with the deposition of drift, rather than that of *glacio-aqueous*, proposed by Prof. Hitchcock in his memoir, not merely for its greater euphony, but because he thought it more expressive of the relations of the transporting media, of which water rather than ice was the predominant, or at least the active agent, and therefore entitled to precedence in a descriptive phrase like this.

A communication was then read from *Dr. Hale*, inviting the Association to make use of the library and rooms of the American Academy. The Association adjourned to

Tuesday, 3½ o'clock, P. M.—*Prof. Wm. B. Rogers* was called to the chair in consequence of the indisposition of the president.

Dr. Jackson exhibited a drawing of the pot holes described by him in the morning, and gave a farther description of the same, and the discussion of the morning was carried on by *Prof. Henry D. Rogers*, *Prof. Emmons*, *Prof. Hitchcock*, *Mr. Redfield*, and the chair.

Prof. Beck read a paper "on certain pseudomorphous or parasitic minerals in the State of New York," on which remarks were offered by *B. Silliman, Jr.*, *Dr. Jackson*, and *Prof. Emmons*.

Mr. Vanuxem read a paper "on the Origin generally of Mineral Springs," which he followed by some remarks on the metal-

liferous ores found by himself in the State of New York, together with some observations in regard to the fissures in rocks.

Association adjourned to Wednesday, 9 o'clock, A. M.

In the evening *Prof. Silliman* delivered a most interesting address on the "Progress of Geological Science in this country," to the Association, in presence of the public, who had been invited to attend.

Wednesday, April 27th, 9 o'clock, A. M.—Association met pursuant to adjournment, *Dr. Morton* in the chair. A letter was read by the secretary from *Mr. Richard C. Taylor.*

The constitution, as reported by the committee on the constitution and by-laws, was then read by the secretary. Articles I, III, and IV, were carried with amendments; the other articles were carried as reported.*

Resolved, That an additional article be prepared by the committee, providing for the future alteration or amendment of the constitution and by-laws.

Resolved, That Prof. Silliman be requested to publish his address before this Association in the American Journal of Science as one of its articles.†

After some remarks on the subject of drift, *Prof. Emmons* offered the following resolution on the subject of drift, which was carried.

Resolved, That the subject of drift in our country receive still farther examination from the committee, and that a farther report be made at the next meeting of the Association. Objections to the views presented and as it has been treated by geologists in general are, that many phenomena are confounded together: as, 1st, the washing up of ridges along the shores of lakes; 2d, those of glaciers; 3d, of icebergs; 4th, alluvial beds; 5th, the accumulation of bowlders along what were ancient coasts; and 6th and 7th, pot holes and slickensides. Icebergs do not necessarily act upon rocks when borne along, inasmuch as they are supposed to be defended by soft materials, as gravel, sand, and mud; and that they explain merely the *distribution of bowlders*, and their peculiar movements when grounded are not likely to form parallel grooves or scratches. The theory of an hemisphere of ice

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* The Constitution will be found under Tuesday's proceedings.

† This address will form the leading article in our next number.—Eds.

capping the whole at least of the northern region is objectionable from the utter extinction of life, especially of molluscous animals, which does not appear to have been the case, as there is an uninterrupted or unbroken series from the eocene to the present.

Resolved, That a committee of three or more be appointed, each to make a distinct report on the subject of drift.

Prof. Emmons, *Prof. Wm. B. Rogers*, *Mr. Vanuxem*, *Mr. Nicollet*, and *Dr. Jackson*, were appointed on the above committee.

Resolved, That all committees which have not reported this year, be instructed to report at the next meeting.

Resolved, That a committee of one be appointed to inquire through all available sources in regard to the influence of icebergs on drift. *Mr. Couthouy* was appointed on the above committee.

Prof. Locke read a paper on the ancient earthworks of Ohio. A discussion followed some remarks of the chairman (Dr. Morton) on this subject, between *Prof. Locke*, *Mr. Nicollet*, *Dr. King*, *Mr. Haldeman*, *Prof. Silliman*, *Prof. Hitchcock*, and *Prof. Bailey*. Mr. Nicollet related several observations relative to the manners and customs of the Indians, made during a long residence in their country, having a bearing on the construction and age of these mounds.

Resolved, That a committee be appointed to examine and report on the subject of western mounds. The following gentlemen were appointed on this committee.

Prof. Locke, *Mr. Nicollet*, *Mr. John H. Blake*, *Dr. Engelman*, *Mr. S. P. Hildreth*, *Prof. Troost*, and *Dr. B. B. Brown*.

Adjourned to Thursday at 9, A. M., the afternoon being appropriated to the delivery of an address before the Boston Society of Natural History, by the chairman of this Association.

Thursday, April 28th, 9 o'clock, A. M.—The Association met according to adjournment, *Prof. Silliman* in the chair. Proceedings of the former meetings were read and accepted.

Resolved, That *Mr. John L. Hayes* be added to the committee on the subject of icebergs, and that he be requested to prepare a separate report.

The committee appointed reported an article relative to amendments of the constitution, which was adopted as a part of the constitution.

Resolved, That on Friday at 9, A. M. the Association proceed to the choice of officers for the next annual meeting, and also to fix upon a place for the same.

Prof. Locke read a paper describing a new instrument invented by himself, and which he called a *Reflecting Level and Goniometer;* he described a reflecting compass of his invention, and read a paper "on a Prostrate Forest under the Diluvium of Ohio."

Prof. Hall made some remarks on the wood found underneath the drift in Washington.

Prof. Hubbard offered some remarks on the drift of New Hampshire, exhibiting a remarkable specimen of a bowlder of smoky quartz containing acicular crystals of rutile.

Resolved, That Prof. Hubbard be added to the committee on drift.

Dr. C. T. Jackson read a paper "on the Tin Veins of New Hampshire," exhibiting specimens of the ore both crystallized and compact, and an ingot weighing three ounces of the reduced metal obtained from five ounces of the ore, the accompanying minerals of the vein at Jackson, also specimens of the yellow blende of Eaton and the black blende of Shelburne, with a specimen of the reduced metal from each, and a specimen of the associated lead ore.

Prof. W. B. Rogers adverted to the occurrence of oxide of tin in Virginia, associated with the auriferous quartz and other minerals of some of the gold mines. As yet he had discovered it at only a few localities. It is in the form of very small crystals scattered at wide intervals, and even where it occurs is perhaps the rarest of all the metallic minerals found in and contiguous to the gold veins. In the two or three instances in which it was found in place, it was imbedded in a talco-micaceous slate, near its junction with the auriferous quartz. The minerals met with in the talcose and micaceous slates, which usually include the veins and beds of auriferous quartz, are auriferous, common, arsenical and cupreous sulphurets of iron, sulphuret of copper, carbonate of copper, sulphuret of zinc, sulphuret of lead, sulphur in minute crystals lining the cavities of cellular quartz, metallic gold, peroxide of iron, phosphate of lead beautifully crystalline, oxide of tin and oxide of bismuth, both exceeding rare.

In connection with Dr. C. T. Jackson's remarks on the occurrence of sulphuret and other ores of zinc in New Hampshire,

Prof. W. B. Rogers mentioned that he had found the sulphuret of zinc sometimes, and the silicate (electric calamine) generally and very abundantly in the lead mines of Wythe Co., Virginia. The *latter mineral* often occupies a great part of the breadth of the vein, lying for the most part beneath the lead ore, sometimes as a sub-crystalline mass and sometimes in groups of small radiating crystals. The *sulphuret* is chiefly met in nests and thin veins, in the sparry and magnesian limestone adjoining the lead ore, and is intermixed with crystals and small seams of galena.

Prof. Rogers added, as a fact of mineralogical interest, that besides the *sulphuret of lead*, these mines yield in some instances quite a large proportion of *carbonate*, of which beautifully pure crystalline specimens are by no means uncommon; and what is still more interesting, they furnish a very considerable amount of *red oxide* or *native minium*, with a small proportion of *yellow oxide*, both of which have hitherto been regarded as very rare minerals. From its resemblance to ferruginous earth or clay, this red oxide was until lately regarded at the mines as worthless, but is now highly valued for its productiveness in metal.

Dr. C. T. Jackson exhibited a specimen of meteoric iron from Claiborne County, Alabama, in which he discovered chlorine in the form of chloride of iron and nickel, in 1834. (See this Journal, Vol. xxxiv, p. 332.)

Prof. J. B. Rogers referred to some analyses of meteoric iron and meteorites recently made by him. A specimen of meteoric iron taken from a mass of many pounds weight in Grayson Co. Virginia, was found to contain 6.15 per cent. of nickel, and gave a very slight trace of chlorine. A meteoric stone from Georgia, made up of shot-like grains of nickeliferous iron with slender flattened threads of the same mineral imbedded in a paste composed chiefly of silicate of magnesia and alumina, gave no indications of chlorine. The grains yielded 7 per cent. of nickel.

Prof. W. B. Rogers stated that he had examined a mass of meteoric iron from Roanoke County, Virginia, and was unable to detect in it the slightest trace of chlorine. A fragment of meteoric stone from Ashe County, North Carolina, examined at the same time, was found to contain a marked quantity of this principle, the presence of which, however, was accounted for by the fragment having been in contact with a bag of salt, as it was carried home by the person who found it.

Prof. Hitchcock read a paper "on a new species of Ornithichnite from the valley of the Connecticut river, and on the raindrop impressions from the same locality."

After Prof. Hitchcock's observations respecting the bird tracks of the Connecticut valley, *Mr. Lyell* alluded to the subject of the cause of the present dip of the formation, expressing the opinion that it is due, in part at least, to an uplifting of the strata.

Prof. H. D. Rogers mentioned the reasons which had induced him to attribute the dip of the beds in the other great tract of this new red sandstone, or that which ranges southwestward from the Hudson, to oblique deposition. A uniform northerly dip of about fifteen degrees prevails entirely across the basin, even where it is twelve or twenty miles in breadth, and coëxists with a manifest shallowness of the deposit. This want of vertical depth is seen in several places in Pennsylvania, where denudation has exposed, in the interior of the tract, large patches of the older Appalachian strata, upon which this new red formation rests unconformably. No traces of dislocation occur to lead to the inference that the shallowness of the basin is deceptive, and that the present want of depth in the deposit has been caused by a succession of upthrows with denudation. The steady northerly dip is very rarely influenced, either in amount or in direction, by any of the numerous dykes of trap which penetrate the formation.

Prof. Rogers next mentioned facts which go to shew that the formation of the Connecticut valley and the equivalent one of the Middle States, are in all probability, accumulations in two originally distinct estuaries. He mentioned as one evidence, the independent direction of the dip in the two basins, and stated that the absence of a parallel order of succession in the members of the two formations, tends likewise to strengthen this opinion.

Mr. Lyell conceived the steepness of the dip, which sometimes amounts to twenty degrees, but more especially its direction,—transverse to the course of the ancient estuary, to present a difficulty. Prof. R. endeavored however to shew that the present dip might have been the original one, by suggesting, first, that there is evidence in the nature of the materials of the great southern basin for believing that they entered the estuary *laterally* on the outcrop side, by streams flowing from a country of decomposing, talcose, chloritic and hornblende rocks; secondly, that if the channel was near the same shore, the velocity of the

tide might have prevented any horizontal deposition far out from the margin; and thirdly, that a gentle and steady *rising* of the region would, in conjunction with the proximity of the channel, tend to maintain both the slope of the sediment and the lateral advance of the shore which the hypothesis requires.

Mr. Benjamin Silliman, Jr., referring to the formation of the Connecticut valley only, considered a part of the present inclination of the beds to be the result of upheaval, connected with the outbursting of the trap.

Prof. W. B. Rogers made some remarks corroborating the views of Prof. H. D. Rogers in their application to the middle secondary or new red sandstone strata of Virginia and North Carolina. He described this group of rocks, consisting of shales, slates, sandstones and conglomerates of various tints of red and gray, as extending with some considerable interruptions in a nearly S. S. W. direction, entirely across the State of Virginia, and for some distance into North Carolina. With but a few local exceptions he had found the dip throughout this belt to be N. W. or N. N. W. Though destitute of the wide and prolonged ridges of trap met with in the corresponding districts of Pennsylvania and New Jersey, this region includes a great number of small dykes and knobs of trappean rock, penetrating the sedimentary strata, but in no instance causing any well marked change of dip in the adjacent beds. The materials of these strata Prof. R. stated to be very clearly traceable to the region of gneissoid and schistose rocks lying to the southeast of the tract, and in some cases, as in the limestone pebbles included in the conglomerate, could even be referred to the individual beds from which they had been torn.

He supported the opinion maintained for some years past by Prof. H. D. Rogers, that the inclination of the strata is not due to a tilting action subsequent to their deposition, but is the simple consequence of the influx of detrital matter from the southeast, and its deposition in a series of northwest-dipping planes. As greatly favoring this view he mentioned the fact generally observed in this belt throughout Virginia, that the strata become steeper in their inclination as we proceed towards the northwest; whereas the reverse should have been expected from a force tilting them from a horizontal or gently inclined position into the present northwestern dips. This opinion he conceived, was still

further confirmed by the appearance of the strata in some parts of the district, where in consequence of the removal of the sedimentary rocks from a narrow space entirely across the tract, he was able to trace the beds from their outcrop nearly to the bottom of the trough in which they were deposited. In this case, he found the inclination of the beds to continue unchanged downwards, instead of becoming more gently inclined towards the bottom, as might be expected on the hypothesis of an originally horizontal position with a subsequent uptilting movement.

Mr. Redfield spoke of fossil rain-marks of a very perfect character which he had observed with Mr. Lyell, at the quarries of new red sandstone near Newark, N. J. He also gave notice of the discovery of a new species of fossil footmark in the new red sandstone of Connecticut. The specimen which he had seen was found in the well known quarries at Portland, (formerly Chatham,) by Mr. Russell, one of the proprietors, and is now in the possession of Dr. Barratt of Middletown. These footmarks are wholly unlike the Ornithichnites described by Prof. Hitchcock, some of which have been found in the same quarries; but they have some little resemblance to the *Cheirotherium minus*, which is figured in the Bulletin of the Geological Society of France.

Mr. Redfield also exhibited a new species of fossil fish from Sunderland, Mass., which seems referrible to the genus *Palæoniscus;* and also called the attention of the Association to a difference of structure in the *Palæonisci* of the Sunderland locality from those of Connecticut in the same formation; while the latter have a perfect resemblance to the fossil fishes of New Jersey. He had also discovered an apparent error in his own printed notice of American fossil fishes, in having named Sunderland as one of the localities of the genus *Catopterus*, as further examinations had led him to doubt on this point; although this genus is more common than *Palæoniscus* in the new red formation, both in Connecticut and New Jersey.

Mr. Lyell and *Mr. B. Silliman, Jr.* offered some remarks on Mr. Redfield's observations.

Mr. John S. Hayes, in explanation of the fossil footmarks in the sandstone of Connecticut river valley, gave some account of the existing species of birds most nearly resembling those supposed to have made those tracks.

As going to show the inclined position of the strata at the time when these impressions were made, *Prof. W. B. Rogers* called attention to a peculiarity in the form of many of these impressions, noticed by himself and Prof. H. D. Rogers in company with Prof. Hitchcock, during the last summer, and often remarked by Prof. Hitchcock on previous occasions. The feature referred to resembles the effect of a slight sliding of the foot in soft clay. It is seen in some of the larger footsteps, both those which point upwards and downwards in reference to the present slope of the rocks, and is even more conspicuous where the animal has been walking horizontally along the inclined surface, in which case there is a protuberance on the downhill side of each impression, as if in virtue of the slope the pressure of the foot had accumulated the soft clay in that direction. Adjourned to

Thursday, 3½ o'clock, P. M.—*Prof. W. B. Rogers* in the chair. A communication from *Prof. Chester Dewey* on the polished rocks of Rochester, N. Y.

Dr. Locke exhibited about eighty colored casts of the fossils found in the western rocks, with explanatory remarks, and upon the advantages to be derived to geological science from the distribution of similar copies.

Mr. James Hall and *Prof. H. D. Rogers* offered some remarks on observations made in connection with Dr. Locke on the same subject.

Dr. King expressed the opinion that the fossils exhibited by Dr. Locke, were not generally the same as those common to the lead-bearing series of the upper Mississippi, and that from his investigations, which had been pretty extensive, he believed that the portion of the formation of that region in which the lead is found, overlies, and is very distinct from what is considered by Dr. Locke to be the *cliff* formation of Ohio. To this *Prof. Locke* replied that the fossils presented by him, were not presented as the fossils of that part of the cliff limestone, containing the lead ore; some of them were actually from the stratum overlying that ore.

Resolved, That the attention of the meeting be strictly confined to the reading of papers, during the remainder of the present session, and that no discussion be allowed thereon.

Mr. James Hall read a paper in connection with a section which he exhibited, of the rocks extending from Cleveland, Ohio, southwesterly to the Mississippi.

Prof. Locke offered some remarks, explanatory of Mr. Hall's opinion on the equivalency of the western formations.

Prof. Hitchcock read a paper on the determination of the silicified trunk of a tree found in the new red sandstone of Connecticut.

The Association then proceeded to the election of a standing committee.

Resolved, That this committee consist of the following gentlemen: *Prof. Edward Hitchcock*, *Dr. Ducatel*, *Dr. C. T. Jackson*, *Prof. Lewis C. Beck*, *Mr. Lardner Vanuxem*, *Dr. J. B. Rogers*, *Prof. J. W. Bailey*, *Prof. John Locke*, and *Prof. B. Silliman*.

Resolved, That *Dr. King* and *Dr. David Dale Owen*, be added to the committee on the western mounds. Adjourned to

Friday, April 29, 9 o'clock, A. M.—Association met pursuant to adjournment, *Prof. Beck* in the chair; minutes of the last meeting read; proceeded to the choice of officers for the ensuing year, according to the resolve of yesterday. The following gentlemen were unanimously elected: *Prof. Henry D. Rogers*, Chairman; *Prof. John Locke*, Treasurer; *Prof. Oliver P. Hubbard*, Secretary.

Resolved, That the next meeting of this Association be held in Albany, N. Y.

The secretary was requested to answer the communication from the National Institute at Washington, inviting the Association to meet in that city.

In consequence of the election of *Prof. Locke* to the office of treasurer, a vacancy was left in the standing committee, he being *ex-officio* a member of that committee. *Mr. John L. Hayes* was elected in his place.

Prof. Wm. B. Rogers, *Prof. Locke* and *Prof. Hitchcock*, were appointed a committee to confer on the subject of the time of the next meeting.

Resolved, That the subject of publication of the abstract of the proceedings of this meeting of the Association, be placed at the disposal of the chairman and secretaries of the present meeting.

A communication was read from *Mr. J. E. Teschemacher*, containing "a description of the oxide of Tin, found at the Tourmalin locality of Chesterfield, Mass."

Prof. Beck read the title of a paper "on some Trappean minerals and the general geological conclusions to be drawn from their history."

The committee on the time of meeting for 1843, reported the fourth Wednesday of April next, which was accepted.

Prof. W. B. Rogers read a paper "on the Age of the Coal Rocks of eastern Virginia." He described these strata as occupying parts of Chesterfield, Powhatan, Amelia, Henrico, and Goochland counties, and lying in basins of granite, the principal coal seam being separated by only a few feet from the floor of primary rock. In some places near the margin of the field, where alone they have been explored, the thickness of these coal rocks is upwards of eight hundred feet, but towards the centre of the principal basin it is probably somewhat greater. Throughout much of this depth they consist of coarse grits, often composed of the materials of granite so little worn as to present the aspect of this rock in a decomposing state. In this paper Prof. R. shows, on the testimony of fossils, and especially the vegetable impressions found in the grits and slates associated with the coal, that these rocks instead of being as had been hitherto supposed of even older date than the great carboniferous formation of the west and of Europe, belong in fact to a much later period and correspond nearly if not accurately with *the bottom of the oolite formation of Europe.* The prevailing fossils are of the genera *Equisetum*, *Tæniopteus*, and *Cycadites* or *Pterophyllum*, and either agree specifically or correspond nearly with those of the *oolite coal of Brora* and the equivalent beds at Whitby and other places. Prof. R. laid much stress on this determination as supplying one of the links in the geological series not hitherto discovered in this country, and as presenting a striking analogy with the abnormal development of the lower oolite in certain parts of Europe. At the conclusion of the paper, Prof. R. stated that from the fossils he has discovered in a particular division of the new red sandstone of Virginia, he expects ere long to be able confidently to announce the existence of beds in that formation corresponding to the *Keuper in Europe.*

Prof. Wm. B. Rogers communicated a paper "on the Porous Anthracite or Natural Coke of Eastern Virginia." In this paper Prof. R. investigates the cause of the peculiar texture and composition of this material, and points out the forms of vegetation

from which both it and the neighboring bituminous coal have been chiefly derived. From the position of the coke beds, as compared with those of the bituminous coal, and the frequent interlamination of the two, he proves that the non-bituminous character of the former could not have arisen from the effects of heat on a seam of bituminous coal, but must be ascribed to the thorough carbonization and desiccation of the vegetable matter before it was *sealed in* by the overlying strata.

Prof. W. B. Rogers communicated a paper "on the Connection of Thermal Springs in Virginia with Anticlinal Axes and Faults." In this paper he gives a list of more than thirty thermal springs, having an excess of temperature over the ordinary constant springs of the neighborhood of from two to nearly sixty degrees, comprising all the distinctly thermal waters which he has thus far met with in Virginia. These are all situated in the Appalachian belt, and *without an exception issue on or near the line of an anticlinal axis or a fault—or near the contact of the Appalachian with the Hypogene rocks.* Prof. R. laid much stress on the fact that the warmest of these springs were generally those which issued from the lowest formations. Accompanying the paper were a series of short sections, illustrating the geological position of a number of the most interesting of these springs.

Prof. W. B. Rogers communicated a paper entitled "Observations on Subterranean Temperature made in the mines of eastern Virginia." In this paper Prof. R. gives the results of observations with the thermometer at depths varying from one hundred to nearly eight hundred feet, all indicating an increase of temperature downwards. Some of these results procured under favorable circumstances, he considers sufficiently accurate to warrant an inference as to the rate of increase of the temperature with the depth in this region. These, it is believed, are the first observations of the kind made in the United States, and, if we except those of Humboldt in Mexico, the first in North America.

Prof. H. D. Rogers offered some remarks on the influence of pyrites on the heat of the strata.

Prof. Hitchcock read a paper entitled "Notes on the Geology of some parts of Western Asia, derived principally from the American Missionaries," and exhibited numerous specimens in illustration of his remarks.

Dr. Dana presented a copy of what was probably the first work on the geology of America, entitled "Beytrage zur mineralogepfer Keintre und des Cëstlicheu theils von Nord America und sum Gebürsge von D. Johamre David Schöpf," presented to the library of the Boston Society of Natural History. Mr. Teschemacher was requested to report on it.

Mr. Couthouy read a paper "on various icebergs as observed by him."*

Mr. James Hall read a paper "on wave lines and other markings on the surface of rocky strata in New York and other places." Association adjourned to 3½ o'clock, P. M.

Friday, 3½ o'clock, P. M.—*Prof. Silliman* in the chair. The following gentlemen were announced by the standing committee as the local committee for next year. *Dr. T. Romeyn Beck*, *Prof. E. Emmons*, Albany, and *Mr. W. C. Redfield*, New York.

A letter from *Mr. James T. Hodge*, relative to the distribution of State Reports, was read by the secretary.

A paper was read "on the Structure of the Appalachian chain, as exemplifying the laws which have regulated the elevation of great mountain chains generally;" by *Prof. Henry D. Rogers*, and *Prof. William B. Rogers.*

The authors divide their papers into two parts; Part I, being a description of the phenomena; Part II, a theory of the flexure and elevation, of the strata deduced from the preceding features of structure.

Part. I, embraces the following heads:

1st. A sketch of the physical features of the Appalachian chain, from New England to Alabama.

2nd. Predominance of southeastern dips, with an historical sketch of the previous explanations offered by other geologists.

3rd. Of the character of the flexures of the strata, and the law of their gradation in crossing the chain northwestward. Two or three new terms are here proposed for designating conditions of structure. The several prevailing forms of structure are then exemplified: (*a*,) normal flexures; (*b*,) folded flexures and inversions; (*c*,) flexures broken on passing into faults.

4th. Of the distribution of the axes in groups; remarkable parallelism of the axes in each group; great length of some axes; bending of

* Mr. Couthouy's remarks have been already given, p. 154–165.

axes; increasing interval between the axes as we advance towards the northwest.

5th. Descriptions of a series of sections across the chain, with a table of the northwest and southeast dips which they disclose.

Part II, treats of the following theoretical topics:

1st. The force producing the flexure and elevation of the strata, was compounded of a wave-like oscillation of the crust, and a tangential pressure towards the northwest.

2nd. Theory of the origin of the supposed subterranean undulations, and of the manner in which the strata became permanently bent.

3rd. Identity of the undulations of the crust with the wave-like motion of the earth in earthquakes. This latter shown to result from an actual billowy oscillation of the surface of the subterranean fluid lava.

4th. Of the geological era of the elevation of the Appalachian chain.

5th. Analogous phenomena of flexures; axes in other countries.

A paper was next read by *Prof. Henry D. Rogers*, entitled "an Inquiry into the Origin of the Appalachian coal strata, bituminous and anthracite." It embraces the following subjects:

1st. A brief introductory sketch of the researches of other geologists in the same region.

2nd. The extent and physical features of the Appalachian coal region.

3rd. The character of the strata; (*a*,) rocks of mechanical or terrestrial origin; the laws of their gradation and distribution; (*b*,) rocks of chemical or marine origin, as limestones, &c.; the law of their distribution; inferences respecting the position of the ancient carboniferous sea and its coast.

4th. Of the coal seams, and the phenomena immediately connected with them; wide range of some of the beds; identified from basin to basin; ancient limits of the coal much more extensive; area of the great Pittsburgh seam, and law of its distribution; present and former areas of the coal strata computed.

5th. Of the intimate mechanical structure of the coal; inferences; persistency of the minor subdivisions of the coal beds inconsistent with the doctrine that the vegetable matter was drifted.

6th. Character of the strata which immediately accompany the beds of coal; prevailing nature of the under stratum, Stigmaria; different composition of the overlying rocks; these latter indicate a rapid motion of the waters, the under clay on the contrary a quiet subsidence of sediment.

7th. Beds of marine limestone in contact with the seams of coal.

8th. Theory of the origin of the coal strata; sketch of the discoveries and opinions of preceding writers; deficiencies in the hypotheses hitherto presented; condition under which the vegetable matter of the coal seams was accumulated; of the part performed by earthquake inundations in producing the mechanical strata; evidences of gradual depressions and risings of the coast of the carboniferous sea; indications of similar alternations of secular and paroxysmal movements of the earth's crust at all geological periods.

9th. Regular gradation in the proportion of volatile matter in the coal as we cross the Appalachian basins northwestward; phenomena connected with it; theory of the debituminization of the coal, and conversion into anthracite.

Prof. W. B. Rogers made a few remarks on thermal springs, as relating to the foregoing subject.

Dr. A. A. Gould, *Dr. Amos Binney* and *Mr. Haldeman*, were appointed a committee to report on the distribution of shells.

Some discussion on the subject of the publication of the Transactions of the Association followed.

Resolved, That *Prof. H. D. Rogers*, *Mr. B. Silliman, Jr.* and *Prof. L. C. Beck*, be appointed a committee to take charge of the whole matter.

The following gentlemen were invited to become members of this Association: *Prof. Johnston*, of the Wesleyan University, *Dr. Barratt*, Middletown, Ct., *Dr. James Deane*, Greenfield, Mass., *Prof. Nichols*, Union College.

Resolved, That the thanks of this Association be tendered to our distinguished chairman, *Dr. Morton*, for his services at the present meeting.

Resolved, That an invitation be given to European societies who may have the same objects in view as our Association, to send delegates to our next meeting.

Prof. Wm. B. Rogers expressed his feeling of great satisfaction at the unanimity and good feeling which had pervaded the present meeting, as well as at the straightforward devotion to science which had marked so strongly all the proceedings of its members. The Association adjourned to

Saturday, April 30th, 9 o'clock, A. M.—Association met pursuant to adjournment, *Dr. Morton* in the chair. Minutes of the last meeting were read.

Prof. H. D. Rogers presented some details in relation to the striated surfaces of the northeastern counties of Pennsylvania, and the adjacent districts of New York, proving that while the scratches which abound on the summits of all the mountain ridges in that part of the Appalachian chain observe a nearly north and south direction, answering to their prevailing course throughout New England and the country of the lakes, those on the sides and bottoms of the valleys, obey with remarkable fidelity all the local deflections which a body of moving waters would encounter among the ridges and valleys of this entangled range. In the neighborhood of the Wyoming valley, the summits of the mountains, elevated about two thousand feet above the sea, and one thousand five hundred above the valley, are covered with nearly parallel striæ, pointing a little west of south, but on their slopes, in the bed of the valley, these lines follow other directions conforming to the course which any obstructed inundation would pursue. Thus, near Wilkesbarre, the northern flank of the southern mountain, which was here exposed to the full brunt of the inundation, exhibits the grooves with a direction compounded of the general meridional one, and that of the deflecting mountain wall. High on the side of the ridge, the striæ ascend the slope obliquely, but nearer the base they are parallel to the medial axes of the valley. Near the lateral notch, in the northern mountain at Nanticoke, they point *toward* the gorge, showing that a portion of the current here came from a quarter south of east. A great northern wave would, so long as it submersed in its first impetuous rush the summits of the mountains, move forward regardless of the local inequalities of the surface, but after it had partially subsided, the long parallel ridges would present so many barriers to divide and locally deflect the now feeble remnant of the drainage. Reviewing the phenomena which he has observed, Prof. Rogers concludes that the striæ were produced by the friction of the overlying stratum of drift itself, urged into rapid motion from the north by one or more sudden inundations. From the absence near the southern border of the striated region of granitic, or other far transported northern bowlders, he infers that floating ice, while it may have been concerned in dispersing the detrital matter from the north, has had no agency in furrowing and smoothing the surfaces of the strata.

The same gentleman next adverted to the origin of conglomerates and other coarse mechanical strata, attributing them in many instances to the similar agency of the sea-wave produced by earthquakes. The wide and uniform distribution of some of the coarser rocks of the Appalachian basin, was appealed to in proof that they could have been spread out as we find them only by a sheet of water as broad as the entire margin of an ocean, breaking in successive sea-waves upon the land, and abrading and dispersing the fragmentary matter during repeated oscillations of the crust.

Prof. Rogers then added some remarks respecting grooved and polished surfaces at the contact of ancient secondary strata. He thinks he has seen unequivocal instances of these in Pennsylvania. Their production at periods when the earth's temperature was manifestly incompatible with the existence of ice, would seem to demonstrate that angular detrital matter, urged by water, is able of itself to score and polish the surfaces of rocks.

Prof. W. B. Rogers continued the illustration of this subject, by calling attention particularly to the evidences of ancient denudation and drifting action, so strikingly displayed along the place of junction of the Oriskany sandstone, (Formation VII, of the Pa. and Va. Reports,) and the subjacent limestones, (Formation VI.) In many districts the limestone has been irregularly denuded, and even to a great extent removed, and at the same time fragments of the limestone and fossils, water-worn and blended with coarse sand and gravel, have been accumulated to form the lower beds of the Oriskany rock. The rapid fluctuation in thickness of the upper limestones, as witnessed in Virginia, Pennsylvania and western New York, (near Black Rock, for example,) Prof. R. ascribed rather to the irregular force of the denudation, than to irregularity of thickness in the original deposit. He dwelt upon the epoch of the close of this limestone series, and the commencement of the overlying sandstone, as one of great interest in the history of our Appalachian rocks, marked as it is, throughout a great part of the Appalachian belt, by evidences of a sudden and great change in the physical conditions of the ancient sea, and by the proofs of attendant drifting and denuding action of extraordinary energy.

He contended that the grooved and worn surfaces of the limestone which mark the abrading action of a drift at this ancient period, together with the same phenomena observed in the rocks

of other portions of the Appalachian series, as described by Prof. H. D. Rogers and Mr. Hall, bear so striking a resemblance to those more recent effects, which have given rise of late to such deeply interesting speculations, that it would seem unphilosophical to refer the two to *different* mechanical causes. He therefore maintained, that as in the production of these ancient phenomena of diluvium or drift, it can hardly be supposed that *ice*, either floating or in the form of glaciers, could have performed any part, since the existence of ice in the ocean at that period is scarcely conceivable, we are under no necessity of resorting to the glacial, or even the glacio-aqueous theory, in explanation of the more modern phenomena of grooved and striated rocks.

Resolved, That *Mr. J. D. Whitney, Jr.* be appointed a committee to be charged with the letters from the secretary to the various foreign societies inviting their coöperation.

The standing committee nominated *Mr. N. Appleton*, of Boston, and *Prof. E. Emmet*, of the University of Virginia, as members of the Association, and they were unanimously elected.

Resolved, That the thanks of this Association be presented to the secretary and assistant secretaries for the performance of the arduous duties assigned them during the present meeting of the Association.

Resolved, That the different state geologists be requested to apply to the legislature of the states with which they are connected, for a number of copies of their reports for the use of the Association.

Resolved, That *Mr. James Hall* be added to the local committee of next year.

Resolved, That the thanks of this Association be presented to the Boston Society of Natural History for the use of their hall as a place of meeting, and for the kind attention shown to the Association by its individual members.

Mr. Couthouy read some extracts from his journal, "on the wave-like undulations of the earth's crust at all periods of disturbance from the most ancient date to the present time," instancing some modern volcanoes.

Dr. Morton, on resigning the chair during the remainder of the meeting, then addressed the Association as follows:

Gentlemen—Before we part, permit me to thank you in the most sincere and grateful terms for the honor you have done me

in permitting me to preside on the present occasion. I can assure you that I have listened with entire satisfaction and instruction to the proceedings of this body, which will fully sustain the high reputation of those gentlemen who have favored us with their communications, and at the same time establish the character of the Association at home and abroad. I look forward with confidence to its widely increasing utility, and with the most earnest desire to coöperate in your future labors, and confident of your success, I again thank you for the distinction you have thus kindly conferred upon me.

Prof. Locke was chosen chairman during the remaining part of the session.

Mr. Couthouy continued his remarks on the range of the volcanoes of the South Sea islands, and in regard to the progressive movement of volcanic action in a fixed direction.

Prof. Locke offered some remarks in regard to the Oulophyllites found on the Wabash river; also on the diamond found in Indiana on ground near and below the coal.

Dr. Amos Binney and *Dr. A. A. Gould* were added to the committee on publication.

Mr. James Hall exhibited sections on Lake Erie, showing broken strata with intermingled drift; he also spoke in regard to wood and bones found in the drift of various parts of the State of New York, particularly in the Genesee river, and in regard to the change which has there taken place in the channel of the river.

James D. Dana, A. M., of the U. S. exploring expedition, was invited to become a member of this Association.

Prof. Locke in resigning the chair remarked:—In parting with the members of the Association, I cannot refrain from adverting to the fine spirit of harmony and cordiality which has characterized the present meeting throughout all of its transactions. To preserve so desirable a condition, it is of the utmost importance that we observe, in all our communications, the most delicate principles of justice to the previous labors and publications of others. It is not sufficient that we may plead that we have not read their productions; we *must* read them, and give credit in order to preserve each his own reputation. To give credit is to acquire credit, and to withhold it is to sink ourselves into disgrace.

I will only add, that my happiness has been vastly increased by the multiplied social attachments which I have here formed. And

in this I presume I express the sentiments of all who have here had the privilege of taking each other by the hand, and of reflecting mutually that look of cordiality which is to be warmly cherished in memory's cabinet until we meet again.

Association adjourned to meet at Albany on the fourth Wednesday in April, 1843. Signed,

SAMUEL G. MORTON, *Chairman.*

CHARLES T. JACKSON, *Secretary.*

JOSIAH D. WHITNEY, Jr. } *Assistant Secretaries.*
MOSES B. WILLIAMS, }

Names and Addresses of Members of the Association of American Geologists present at the Third Annual Meeting in Boston, April 25–30, 1842.

Lewis C. Beck, *New Brunswick, N. J.*
J. T. Ducatel, *Baltimore, Md.*
Lardner Vanuxem, *Bristol, Pa.*
J. N. Nicollet, *Baltimore, Md.*
H. King, *Washington City.*
Henry D. Rogers, *Philadelphia, Pa.*
John Locke, *Cincinnati, Ohio.*
E. N. Horsford, *Albany, N. Y.*
F. Hall, *Washington, D. C.*
Oliver P. Hubbard, *Hanover, N. H.*
Charles T. Jackson, *Boston, Mass.*
J. W. Bailey, *West Point, N. Y.*
Abraham Jenkins, Jr., *Barre, Mass.*
Wm. C. Redfield, *New York City.*
Moses B. Williams, *Boston, Mass.*
James Hall, *Albany, N. Y.*
Josiah D. Whitney, *Northampton, Mass.*
Samuel L. Dana, *Lowell, Mass.*
S. S. Haldeman, *Columbia, Pa.*
H. C. Perkins, *Newburyport, Mass.*
Enoch Hale, *Boston, Mass.*
B. Silliman, *Yale Coll., New Haven, Ct.*
Robert W. Forbes, *New Haven, Ct.*
B. Silliman, Jr., *Yale Coll., New Haven, Ct.*
Charles Lyell, *London.*
Joseph P. Couthouy, *Boston, Mass.*
John L. Hayes, *Portsmouth, N. H.*
John H. Blake, *Boston, Mass.*
Augustus A. Gould, *Boston, Mass.*
Charles H. Olmsted, *Hartford, Ct.*
John Lewis Russell, *Salem, Mass.*
Francis Alger, *Boston, Mass.*
Edward Hitchcock, *Amherst, Mass.*
Ebenezer Emmons, *Albany, N. Y.*
R. M. S. Jackson, *Alexandria, Hunt. Co., Pa.*
Wm. B. Rogers, *University of Virginia.*
James B. Rogers, *Philadelphia, Pa.*
Henry Colman, *Rochester, N. Y.*
Owen Mason, *Providence, R. I.*
Amos Binney, *Boston, Mass.*
Martin Gay, *Boston, Mass.*
J. B. S. Jackson, *Boston, Mass.*

ART. XV.—*A Daguerreotype Experiment by Galvanic Light;* by B. SILLIMAN, Jr., A. M., of the departments of Chemistry and Mineralogy, in Yale College, and WM. HENRY GOODE, M. D.

IN November, 1840, we succeeded in obtaining a photographic impression, by galvanic light reflected from the surface of a medallion to the iodized surface of a Daguerreotype plate. The large battery in the laboratory of Yale College, consisting of nine hundred pairs of plates, ten inches by four, was charged with a weak solution of sulphuric acid, and its poles adjusted with charcoal points, in the manner which is customary, when an intense light is to be produced by means of this instrument. Two pictures were obtained; one of which is made up of a blur, or spot, produced by the light from the charcoal points, the image of the retort-stand, on which a medallion of white plaster rested, and the image of the medallion, but the lines on its face are not given. The camera was about six feet from the charcoal points, when this impression was taken, and the medallion a little on one side, and in the rear of the points. The plate was exposed to the light about twenty seconds, and no means were employed either for condensing the light on the objects to be copied, or that reflected from them, on the lens which gave the image. The only lens employed was a French achromatic, three inches in diameter, and of about sixteen inches focal length. Another picture was taken of the medallion only, which was placed about two feet from the charcoal points, and the camera about four feet from it, and in such a position that the charcoal points did not come within the field of the lens. This picture, we regret to say, has been inadvertently destroyed. The plates used were of inferior quality, being some of the first of American manufacture.

These experiments were not published at the time they were made, because it was understood, that a gentleman distinguished for his scientific investigations, was already engaged in studying this branch of the subject, with whose researches we had no wish to interfere, and the matter was abandoned mainly for this reason. Having been informed recently, however, that this gentleman had also abandoned it, we have concluded to give this account of our experiments.

On the same occasion, an observation was made respecting the image given by the two charcoal points, when they were nearly in contact, and the battery in full operation, which we do not remember to have met with elsewhere. An image of each charcoal point is given, separate from that of the other, by a lens placed at a little distance. These two images differ remarkably in color; one is of the color of the flame afforded by the combustion of an alcoholic solution of strontia;

the other resembles in color, the flame produced by the combustion of an alcoholic solution of chloride of sodium, more nearly than any thing else with which we can compare it. The charcoal points were shifted, each to the opposite pole of the battery, without producing any change in the color of the light given off by the poles respectively. Other pieces of charcoal were substituted, in the place of those with which this phenomenon was first observed, but the difference in the color of the two images was always present, and did not seem to be connected in any manner with the particular charcoal points employed, but the yellow image was uniformly given by one pole, and the purple image by the other pole of the battery. We are under the impression, that the yellow colored image was produced from the charcoal point, in connection with the positive pole of the battery, and that the strontia colored image came from the negative pole of the battery, though of this no note was made at the time. No attempt was made to ascertain by direct experiments, whether these images possessed a different degree of power or not, in producing an impression upon an iodized plate. The difference in their color was presumptive evidence that one image, (that from the negative pole,) possessed more of the chemical rays than the other. But evidence is (we are of opinion) afforded indirectly that such is the fact. The light from both charcoal points made a slight impression on the iodized plate, before they were brought so close together as to unite in forming a general blur: these two small spots or impressions are nearly opposite, or at each extremity of one diameter of the blur, and without its circumference; one of them is more distinct than the other. Within the edge of the blur, and nearly in the same diameter with the two spots above named, there are also two impressions, darker and more strongly marked, than is the general impression made by the light from the points. One of these spots is doubtless made by the light from one point, while the other is due to the light from the other point, and one of them far exceeds the other in distinctness. Now the more strongly marked spot without the blur, and the more strongly marked one within it, are close to each other on the same edge of the blur, and are doubtless produced by the light from one and the same charcoal point. The two other spots, viz. that without, and that within the blur, which are much less distinct, are close to each other at the opposite extremity of the diameter of the blur, and are also evidently produced by the light from the other charcoal point.

Yale College Laboratory, June 20, 1842.

ART. XVI.—*Discovery of a Chambered Univalve Fossil in the Eocene Tertiary of James River, Virginia;* by M. TUOMEY.

THINKING that it may have sufficient interest for the pages of this Journal, the following notice of the discovery of a Nautilus in the Eocene on James River, Va., is communicated.

Mr. Lyell during his visit to this portion of the tertiary of the United States, directed my attention to the broken link in our great cretaceous formation, presented by Virginia. At his suggestion, I determined to observe any fossils that may come under my notice, with a view to the elucidation of this interesting point. The liberality of Capt. H. H. Cocke, U. S. N., afforded me a good opportunity of examining the fossils of the well known eocene locality at Evergreen, near City Point, James River. Capt. C. at the instance of Edward Ruffin, Esq. editor of the Farmer's Register, who is engaged in the investigation of the tertiary of Lower Virginia, caused a shaft to be sunk at the base of the escarpment at the locality just mentioned. In this shaft and at a depth of about twenty feet below the level of tide water the fossil referred to was found. It was imbedded in the dark colored tenacious clay containing much green sand, common to some of the eocene strata of this region. The exterior of the shell is much decayed, but the pearly surface of the interior is well preserved, and by removing portions parallel to the aperture the concave septæ and siphunculus can be seen. It was associated with eocene species of Turritella, Crassatella, Pectunculus, a small Panopæa, and a little lower in the same stratum was found a gigantic Ostrea, measuring in height eight and a half inches, breadth five and a half inches, and weighing five pounds. The *upper* valve of this Ostrea agrees with the description of O. percrassa, Conrad, but in the lower valve the cartilage fosset is deep. The muscular impression in each valve exhibits a cavity extending upwards into the substance of the shell about two inches. A person seeing but this huge individual, and the common form of O. compressirostra, Say, found in the same stratum, would pronounce them distinct species; but I am in possession of a suite of specimens showing the intermediate forms between the two, and am convinced that this enormous fossil is but a full grown O. compressirostra.

Petersburg, Va., June 10, 1842.

ART. XVII.—*Bibliographical Notices.*

1. *New edition of Michaux's North American Sylva.*—The first volume of this work, (announced on page 377 of the last volume,) has at length appeared. The text is reprinted verbatim, from Hillhouse's translation; Mr. Nuttall's additions being reserved for the supplementary volumes. The engravings (No. 1 to 50,) which are handsomely colored impressions from the original plates, will bear comparison with those of the former edition: this, we are sorry to add, is more than can be said of the paper and typography of the text, which are truly wretched. We trust that Mr. Nuttall's portion of the work, at least, will make its appearance in a more attractive dress.

2. *Loudon's Encyclopædia of Trees and Shrubs; being the Arboretum et Fruticetum Britannicum, abridged, &c.* London, 1842.—Since our notice of the first fasciculus, (p. 376 of the last volume,) this truly valuable work has been completed, according to the original announcement, in ten monthly parts, forming a volume of 1162 pages octavo. It contains the characters, synonymy, popular names, as well as popular descriptions, of all the species and varieties of hardy trees and shrubs, now in British gardens, with directions for their culture, and notices of their uses in the arts, &c. The volume is illustrated by 2109 wood engravings, the indefatigable author having been able to obtain figures of nearly all the species described in it. Although this abridgment does not include all the interesting information to be found in the eight volumes of the larger work, "yet it contains all that is necessary for discovering the names of the different species, and for ascertaining their culture, propagation, and uses in Britain; in short, all that is essential for the nurseryman, gardener, and forester."

3. *Flora Rossica, sive Enumeratio Plantarum in totius imperii Rossici provinciis Europæis, Asiaticis et Americanis hucusque observatarum:* auctore CAR. FRID. LEEDEBOUR, Bot. Prof. Emer. &c. &c. Stuttgart, (Schweizerbart,) Fasc. I, 1841, pp. 240, 8vo.—A Flora of the Russian dominions, is indeed a formidable undertaking; and, combined with a complete Flora of North America, would comprise a large part of the botany of the extra-tropical portion of the northern hemisphere. Following the arrangements of De Candolle, the first fasciculus of Dr. Leedebour's work, includes the orders from Ranunculaceæ to Cistaceæ; the former, with the Cruciferæ, occupying the greater part of the number.

4. *The London Journal of Botany;* edited by Sir Wm. Hooker. This is the title of a new monthly periodical, commencing in January last, which takes the place of *Hooker's Journal of Botany*, and is in fact, a continuation of that excellent work, in the hands of a new publisher, Baillière, who we understand, will continue the publication of this author's *Icones Plantarum.* We have more than once called the attention of our botanical readers to both these works. This indefatigable botanist has also announced, as nearly ready for publication, the first part of a new treatise upon a favorite family of plants, viz. a *Species Filicum*, or synopsis of all the known species of Ferns, with generic and specific descriptions of each, and plates containing several figures upon each plate. Only the rarest and most interesting species are to be figured, particularly such as have not yet been represented in any published work.

We may also state, that Prof. Kunze of Leipsic, is publishing, in occasional numbers, a supplement to Schkuhr's work upon Ferns, (the first volume of his *Vier und zanzigste Klasse des Linnèeischen Pflanzensystems, oder Kryptogamische Gewächse.*) Of Prof. Kunze's continuation, entitled *Die Farrnkräuter in koloriten Abbildungen naturgetsen erlautert und beschrieben*, four fasciculi have reached us, each containing twenty pages of text, (4to,) and ten finely colored plates.

5. *Kunze, Supplemente der Riedgräser (Carices) zu Chr. Schkuhr's Monographie, &c.*—We have already noticed the first fasciculus of this work, (Vol. xli, p. 374.) In the second, which has just arrived, the following species are handsomely figured, viz. *C. appressa*, *C. echinochloe*, *C. Antucensis*, *C. lepidocarpa*, *C. fuliginosa*, *C. vaginata*, *C. pediformis*, *C. clavata*, *C. provincialis*, *C. excelsa*, and *C. curvirostris.* C. fuliginosa is the only one of this number, known to be indigenous to North America, although C. pediformis has been found in Kamtschkatka.

6. *Memoir on a portion of the lower Jaw of the Iguanodon and of the remains of the Hylæosaurus and other Saurians, discovered in the Strata of Tilgate Forest in Sussex, (England,)* by Gideon Algernon Mantell, Esq. L.L.D. F.R.S., author of the Wonders of Geology, &c. *Fossil Remains of Turtles discovered in the Chalk formation of the Southeast of England*, by the same author.—These beautiful memoirs are a part of the Transactions of the Royal Society of London; they are illustrated by eight quarto plates, and contain full and exact descriptions of the objects to which they relate. They are marked by all that precision, discrimination and accuracy for which the author is distinguished, combining minute details of comparative anatomy, with just and

enlarged philosophical views, with respect to the extraordinary creatures which Dr. Mantell has rescued from the darkness of ages, and restored to their proper position in the creation. Those who would know the full bearing of the facts, especially those regarding the extinct saurians, must peruse the larger works of the author, his Tilgate Forest, his Geology of the Southeast of England, and his Wonders of Geology. We are truly sorry to have him terminate his memoir on the Iguanodon, by adopting the words of Cuvier: "Je termine ici mes travaux, et je laisse à mes successeurs à cultiver un champ que je n'ai fait qu'ouvrir, et qui bien certainement leur donnera encore des moissons plus riches que toutes celles que j'ai pu recueiller."*

7. *Treatise on Algebra;* by THOMAS SHERWIN, Principal of the English High School, Boston. (Communicated.)—Among the publications designed for the instruction of youth, which are daily issuing from the press, our attention has been recently directed to the elementary work named above. We think this work cannot fail to find its way to the favor of all who give it a careful perusal. The author, in his preface, modestly acknowledges his indebtedness to several preceding works of the kind, particularly that of Colburn, the favorite of the Massachusetts school-room, which, however, it surpasses in the number of examples for practice. These are so numerous, and so well chosen, that we are confident that a careful and correct solution of them will secure to the student something beyond a merely superficial knowledge of the subject. In the earlier part of the work, we were particularly pleased with several sections. One on the subtraction of negative quantities, which we remember in our school days was considered a most intricate subject; another on the "greatest common divisor," the reasons of which are seen in the school arithmetics as through a glass darkly; and a third on generalization, then held in almost reverential awe. Of the more advanced sections, we were pleased with those on negative exponents, and the unusually numerous examples in this department, will be found very useful. We were interested with the section on inequalities, and with that on ratios, of which Colburn and some other writers say nothing. The section on logarithms, without entering on the tedious calculations necessary in the actual formation of tables, gives a very good idea of the manner in which they may be constructed, and forms a happy introduction for those who desire to become better acquainted with the more abstract treatises. The miscellaneous examples at the last of the work, serve as a recapitulation of the whole, and a test by which the learner may judge of the degree of

* Recherches sur les Ossemens Fossiles, tom. v, p. 526.

thoroughness with which he has read each section. Finally, a long experience in one of the best schools in New England, has enabled the author to succeed most happily in adapting this work to the purposes of instruction.

8. *Practical Geology and Mineralogy, with Instructions for the Qualitative Analysis of Minerals;* by JOSHUA TRIMMER, F.G.S. Am. Ed., by Lea & Blanchard. pp. 527, 8vo.—We have read parts of this work, and looked over its plan. It appears to be exact, comprehensive, scientific, and practical. Its principal heads are—

Introduction; Practical Application and Uses of Geology; its discoveries not opposed to religion.

Materials of the Crust of the Earth.

Simple Bodies; External characters of Minerals; Chemical characters.

Minerals composing the Crust of the Earth; Order of arrangement of the Materials of the Crust of the Earth.

Classification of Rocks; Explanation of Terms.

Unstratified Rocks; Stratified Rocks.

Classification of the work.

Primary or Non-fossiliferous Strata; Fossiliferous strata.

Cambrian System; Silurian System.

Carboniferous System; Coal Fields of England.

Poikilitic (upper red sandstone) System.

Oolitic System; Wealden.

Cretaceous System; Tertiary System.

Modern Group, River Deposits.

Coral Formation; Igneous Rocks.

Temperature of the Interior of the Earth.

Present state of the Geological Theory.

Summary of admitted facts and inferences in Geology.

Conclusion; Postscript; Glossary; Index.

The order is good in the main. There are many advantages in introducing the igneous rocks and the dynamics of fire first, as we have then all the great agents at our command, for the interpretation of the phenomena of the stratified rocks. The work is neatly got up with a good type, and a paper reasonably white, but too thin and tender, as our American reprints are wont to be; and we have had much occasion to find fault with many republications of foreign works, on account of an inferior and slovenly style, although there are honorable exceptions. If we will persist in denying copyright to foreign authors, it is at least due to them that their reprinted works should appear in a good style.

9. *A Muck Manual for Farmers;* by SAMUEL L. DANA. Lowell, Daniel Bixby, 1842: pp. 216. (Communicated.)

Dr. Dana has long been known as one of our most accurate and learned chemists; and his professional duties, as connected with the large calico printing establishment at Lowell, have led him to make many careful experiments upon subjects bearing directly upon agricultural chemistry. He has written this work, therefore, in the full maturity of experience and judgment. His statements and reasonings are not those of a novice, but we see at once that he has looked at every point again and again, and that he gives us the final conclusions of long and patient examination. It is well known that on many points the theory of this science is not fully settled. The author, however, shows, (and this we regard as a most valuable part of his labors,) that these different views are of very little practical importance. His own peculiar opinions he states with great frankness, and merely gives a summary of arguments on which he founds his conclusions, with scarcely any personal allusion to those of different views.

The condensation of matter in this volume is one of its marked features. The amount of facts and reasonings brought into so small a compass is truly astonishing. We think it is sometimes carried to an extreme; that is, it produces obscurity. It is truly a book of aphorisms. There is so much of generalization, indeed, that we suspect the author will sometimes be misunderstood. It would not be strange if this very notice should furnish some examples.

The present work is a very original one. The author's views, generally, do indeed correspond with those of the most distinguished chemists. But he has his own method of stating, proving, and correcting them; and we have been agreeably surprised to see how straight and luminous a path he has cut through the entangled vines and brushwood of this subject. A brief account of his arrangement and elementary principles, will give our readers some idea of his manner and matter.

The whole work is divided into eight chapters. 1. The Geology of Soil. 2. The Chemistry of Soil. 3. Properties and Chemical Action of the Elements of Soil. 4. Of the Organic Constituents of Soil, with an Appendix, containing the History of Geine. 5. Of the Mutual Action of the Organic and Inorganic Elements of Soil. 6. Manures. 7. Artificial Manures and Irrigation. 8. Physical Properties of Soils. In the first five chapters he announces, defends and illustrates ten fundamental principles, which constitute the essence of agricultural chemistry. These we shall copy, with a few remarks upon some of them.

The first principle is, "*that there is one rock, consequently one soil.*" It is true, that the later rocks contain from 4 to 7 per cent. of lime and

magnesia more than the older ones; but since all of them contain enough of these and other mineral ingredients for the wants of plants, an excess of some of them cannot sensibly affect vegetation. The mineral composition of this "one soil," by a mean of numerous analyses, the author states to be, in 100 parts, 89.25 of sand, or silicates, and 0.85 salts of lime.

Thus far we agree essentially with the author. But there are some other facts, which lead us to question whether the statement of this first principle does not require modification. It cannot be doubted, in the first place, that some silicates, (varieties of feldspar, for instance,) are decomposed, both by atmospheric agencies and by growing plants, with much more facility than others; and consequently vegetation obtains from some soils the alkali, lime, and silica, which it needs, more easily than from others. In the second place, where an extensive region is underlaid by limestone, a large per cent. of the soil (from 5 to 30 in some parts of Europe) consists of carbonate of lime, and this is usually more easily decomposed than silicates, and will more readily supply carbonic acid.

The second principle is, that "*rocks do not affect the vegetation which covers them.*" Here again, while we agree with the author that this principle is generally true, far more generally so than is commonly admitted, we would suggest to him whether there are not exceptions to it, too important to be overlooked in stating it. A similar difficulty we feel in respect to his third principle, that "*rocks have not formed the soil which covers them.*" And we can conveniently, perhaps, state our exceptions to both of them in the same paragraph.

It is true that what has been called diluvial action, as well as alluvial agency, has mixed up the detritus of different formations, and spread the soil derived from one rock over others. But the great mass of the soil has in very few cases been removed more than a few miles, although single bowlders have been carried hundreds of miles. Hence, when we have gone a few miles from the borders of a formation, the soil is made up almost entirely of its pulverized fragments, removed, it may be a short distance, but still derived from precisely the same rock as that beneath it. Again, limited formations are sometimes so situated that little if any foreign detritus has been left upon them, as for instance, the trap ranges along Connecticut river. From both these causes it happens, that over a large part of our country, each rock formation of much extent, does present a peculiar soil, which the geologist easily recognizes as derived from the subjacent rock. That above granite and gneiss, for instance, is light colored and sandy; that from argillaceous and mica slate, dark colored and clayey; that from trap rock, brown and finely comminuted, but not argillaceous. We cannot but believe, therefore, that the statement, that *rocks have*

not formed the soil which covers them, is far too general in its terms. And if the preceding statements are correct, we must believe that *rocks do sometimes affect the vegetation which covers them.* We believe there is some truth in the common opinion, that limestone regions are more prolific of vegetation than any others. How very different is the Flora of the trap ranges in the Connecticut valley from that of the primary ranges of equal height on the sides of the valley! How different the oaks, maples, beeches, and hemlocks of the Hoosac mountain, from the chestnut groves of the Taconnic! Must not these differences be in part imputed to the peculiarities of the soil derived from the rocks?

The author refers to the cultivation of the different sorts of grain on all soils and in all the temperate regions of the globe, as proof that rocks do not affect the vegetation above them. But some species of plants, like some species of animals, are adapted by the Creator to almost all climates; and as man is one of them, we should expect a beneficent Providence would give the same power to those *cerealia*, which furnish him food. But let us attempt to cultivate the numerous peculiar species found in particular localities in all places where grain will grow, and we should fail in nine cases out of ten. Does this argument then from the cereals prove the point? Would not the argument from the other species referred to, be equally good on the other side? But we have neither time nor space to say all on this subject which we could wish.

The fourth principle of agricultural chemistry is that "*all soils contain enough of lime, alkali, and other inorganic elements, for any crop grown on them.*" We are constrained to say that we could wish this rule also were expressed in terms less general and sweeping. To prove it, the author has taken a strong case,—the soil of a barren pine plain. He supposes it formed of the drift of granite, which, upon an average, contains seven and a half pounds of potash, and three eighths of a pound of lime. An acre then, six inches deep, would contain **3626** pounds of lime, and **73311** pounds of potash.

Granting the premises, the conclusion is irresistible. We will admit that the soil of a pine plain may have been originally derived from the disintegration or abrasion of granite. But let almost any soil of this description be examined, and it will be found that the feldspar and often most of the mica have nearly disappeared; while little remains but grains of quartz, which contain neither lime nor alkali. Thus nearly all of these ingredients may be removed from a soil; and such we apprehend to be the fact in respect to the soil of most barren, sandy plains. Most feldspars, it is well known, decompose with great readiness; and in our opinion, it is from this mineral rather than the mica, that plants derive their supply of lime and potash.

We have made these exceptions to Dr. Dana's rules, not with a view to prove them entirely erroneous, but to suggest to the author, whether in another edition, they may not be so modified as to obviate all objections. Even in their present state, we regard them as nearer the truth than the notions that widely prevail. But we think they can be improved.

The fifth principle of agricultural chemistry asserts, that "*all soil contains sulphate and phosphate of lime.*" For the discovery of this important principle, agricultural chemistry is indebted to Dr. Dana. It was first announced in the Report on the Economical Geology of Massachusetts, written in 1837 and published in 1838, and is there accompanied by what Dr. Dana calls the "agricultural proof;" that is, the evidence derived from the composition of plants. This evidence was abundantly confirmed by the analysis of no less than one hundred and forty six soils from every variety of formation in Massachusetts. In all these soils, (except one, which was entirely made up of pure limpid quartz in the form of sand,) sulphate and phosphate of lime were found. (See final Report on the Geology of Massachusetts, Vol. I, p. 41.) The difficulty of detecting the phosphates had produced the belief that they exist only in a few soils. But the admirable rules given by Dr. Dana on this point, enable any chemist to satisfy himself that almost every plant-bearing soil contains phosphates, usually less than one per cent. In Liebig's Organic Chemistry of Agriculture, &c. published in 1840, this same principle, so far as phosphoric acid is concerned, is advanced; but whether the result of his own discoveries or of a knowledge of Dr. Dana's announcement, nearly three years earlier, does not appear.

The sixth principle is, that "*soil, consisting chiefly of one silicate, or salt, is always barren.*

The seventh principle is, that "*one base may be substituted for another in an isomorphous proportion.*" These "isomorphous substitutions in plants relate only to the vegetable or organic acids;" yet the principle holds true in respect to the inorganic parts of soils, and admits of several important applications made with great ingenuity by the author. But our limits compel us to pass them unnoticed.

The eighth principle is, that "*geine in some form is essential to agriculture.*" As discussions perplexing to the farmer have arisen in our country respecting geine, Dr. Dana has thought it necessary to be very explicit as to the sense in which he uses the term; and he has added an appendix to the chapter on this subject, detailing its history. He uses the term in two senses, viz. an agricultural sense and a chemical sense.

"In all its forms," he says, "it is agriculturally one and the same thing. They are all included in the terms humus, or mould, or geine.

Geine, in its agricultural sense, is a generic term. It includes all the decomposed organic matter of soils." p. 62. In a chemical sense, he maintains that "the great mass of organic matter of soil is a well defined chemical compound termed geine, consisting of carbon, hydrogen, and oxygen." p. 60.

Agricultural geine, then, we understand to be the equivalent of the humus and mould of other chemists, and to embrace the extract of mould, the humic acid, humin, crenic and apocrenic acids, and whatever other compound has resulted from the decomposition of the organic matter of soils. Agriculturally, these may be all regarded as the same thing; and the farmer may be assured, that "differ as opinions may about its ultimate chemical constitution and the mode of action of geine, whether by being taken up as a solution of geine or geates, or only as a source of carbonic acid, the great practical lesson of all agricultural experience, teaches that geine is essential to the growth and perfection of the seed; that without geine crops are not raised. Geine is as essential to plants as is food to animals." p. 61. Some of the ablest chemists, as Liebig and Graham, do not admit the distinct existence of crenic and apocrenic acids, enumerated above as compounds found in soils: others regard extract of mould and humin as mere forms of humic acid. But such questions are of little practical agricultural importance, and may be safely left to the chemists to settle. Dr. Dana has an opinion on these points, and his *chemical geine*, as we have seen, is "a well defined compound," embracing the humic acid, the humin and extract of mould of Berzelius, and the sacchulmic acid and sacchulmin of Liebig. Berzelius, it is well known, originally gave the name geine to this compound, in the French edition of his works published in 1832; and the same name is retained in Esslinger's French translation of his *Traite de Chimie*, published in 1840, which lies before us. But very recently, it would seem, he has substituted *humic acid* for geine; a mere change of name, but not of opinions respecting the nature of the compound. Indeed, the distinct and definite nature of this substance seems to be admitted by as high chemical authority as almost any organic compound can claim, although the name is not yet settled.

The ninth principle of agricultural chemistry asserts that "*carbonic acid and the carbonates, decompose the earthy, alkaline, and metallic silicates of soils.*" This is an exceedingly important principle, and applicable especially to the agriculture of primary regions.

The tenth principle is, that "*the base of all salts acts ever the same in agriculture. Peculiarity of action depends on the acid of the salt.*" This the author regards "in all its length and breadth, *as the great practical principle of agricultural chemistry.* It opens veins rich in

results, more precious than mines of gold." This is no idle boasting. The author in a chapter of thirty seven pages, on *the Mutual Action of the Organic and Inorganic Elements of Soil*, has opened some of these mines—enough to bring up to view rich samples of the golden ore. In plain language, we have never met with so luminous and satisfactory a view of the mutual and complicated action of silicates, salts, and geine, as this chapter presents. Gladly would we lay before our readers an analysis of its contents, but we must forbear.

Similar remarks will apply to the still longer chapter on manures, and to that on artificial manures. For the numerous analyses by the author of several sorts of manure, and the important results he hence deduces, and for the important suggestions he makes as to artificial manures, he deserves the gratitude of his country and the patronage of its government. For if heeded by the farmer, the doubling at least of our agricultural productions will undoubtedly be the result, and few farmers can read these chapters without being convinced that "rivers of riches run away from farms from want of attention to saving that which ordinarily is allowed to be wasted." p. 175.

In conclusion, we can cordially recommend this work to our agricultural friends for its practical character. It is not saying too much to assert, that Dr. Dana has done for the farmer in this treatise, what Dr. Bowditch did for the sailor when he published his Practical Navigator. In this respect this treatise contrasts strongly with such a work as that of Liebig on the Organic Chemistry of Agriculture, &c. which, notwithstanding its originality and the philosophical beauty of its theories, is apt to make the impression upon the farmer that he is not at present to expect much from agricultural chemistry but ingenious conjecture. We are sure that Dr. Dana's work will remove this impression, while on the other hand, the chemist will see in it evidence of the rapid advance of this science. Within two years, three able European chemists, Liebig, Daubeny, and Johnston, have given to the world most mature and valuable treatises upon it; and now we have a cis-Atlantic effort, which will not suffer by a comparison with any other. Truly the genius of agriculture may exult in the bright prospects that are opening before her.

10. *Address delivered at the Anniversary meeting of the Geological Society of London, Feb.* 18, 1842; *and the announcement of the award of the Wollaston Medal and Donation fund for the same year;* by Roderick Impey Murchison, F. R. S., President of the Society.—The annual addresses at the anniversaries of the Geological Society of London are full of instruction. That of the present year is not a whit behind its predecessors, and is every way worthy of its distinguished

author. With the frankness and generosity which belong to his character, he bestows upon *Leopold Von Buch*, the veteran geologist of Prussia, the well deserved honor of the Wollaston medal, and annexes to the annunciation a sketch of those numerous and important labors of his, which are less known than his great classical works.

He announces also the bestowment, by the council of the Geological Society, of the Wollaston fund for the past year upon Mr. Morris, to assist him in preparing a table of British organic remains. In the painful duty of naming members who have died during the late year, he mentions, with just eulogy, the name of Sir Francis Chantrey, the great sculptor; Mr. J. E. Bowman, whose valuable papers in the Transactions of the Manchester Geological Society we have perused with much interest and advantage; also, Mr. Thomas Edington of Glasgow, Mr. Snow of Highgate, Dr. Yelloly, and the Rev. Mr. McEnery.

The President having returned from a second geological tour through Russia, (mentioned in Vol. XLI, p. 207,) announces with well merited satisfaction, the vast expansion of the Silurian system in that empire, and in many other parts of the world, but above all other foreign countries, he remarks, "North America appears to be rich in rocks of the same age. Of this fact, indeed, the Geological Society received the clearest evidence in the excellent section of Mr. James Hall, and the fine suite of American minerals which accompanied it." In a note he adds, "I was very much struck with the clear, unpretending and workmanlike manner in which Mr. Hall had the kindness to communicate his views to myself, respecting the Silurian and other Palæozoic rocks of the United States."

He objects, and we think with good reason, to an attempted subversion of his own nomenclature of the lower fossiliferous rocks, which he, being the first thoroughly to explore, had a full right to name; the geological world has acquiesced in the designation, and we trust that even the justly respected authority of Mr. Phillips will not avail to subvert it.

Of a recent work by Mr. Hugh Miller, in a 12mo. with plates and colored sections, entitled, "*The Old Red Sandstone, or New Walks in an Old Field*," he thus speaks in terms of merited commendation: "From a pretty accurate acquaintance with the tracts from which Mr. Miller has taken his title, I can assure you, says Mr. Murchison, that the walks of this author had been little trodden, and that his claims to originality are very just. It is impossible to peruse these pages without delight, in tracing how the strong mind of Mr. Miller has enabled him to rise, step by step, from the stone quarry of his—and I may add my own—native county, Ross-shire, to a place in literature and science which few reach,

even with all the support derived from an expensive education; or without admiring the ability with which this unassisted observer first succeeded in putting together the dislocated fragments of the very singular fish, called Pterichthys, by Agassiz, long before that creature was first understood. Look again to the clear and general view which this author takes of the greatest of Scottish deposits, and how well he conveys to unpracticed readers a true idea of its position, importance and divisions, and you will agree with me, that in Mr. Hugh Miller we have to hail the accession to geological writers, of a man highly qualified to advance the science. Few persons, and too often least of all those who are, if I may so speak, professed geologists, succeed in imparting to others, who have not studied the science, a clear conception of their views. In this respect the character of Mr. Miller's work is admirable, for it portrays the means by which the author acquired his knowledge, and from its persuasive manner, is worth to a beginner, a thousand didactic treatises." Professor Buckland, before the British Association, said, that "he had never been so much astonished by the powers of any man as he had been by the geological descriptions of Mr. Miller. That wonderful man described these objects with a felicity which made him ashamed of the comparative meagreness and poverty of his own descriptions, which had cost him hours and days of labor. He would give his left hand to possess such powers of description as Mr. Miller, and if it pleased Providence to spare his useful life, he, if any one, would certainly render the science attractive and popular, and do equal service to theology and geology."

In our turn we take leave to add, that this admirable work, the production of a man who obtained his geological knowledge while working, day by day, as a laborer in a quarry of the old red sandstone in the northeast part of Scotland, evinces talent of the highest order, a deep and healthful moral feeling, a perfect command of the finest language, and a beautiful union of philosophy and poetry. No geologist can peruse this volume without instruction and delight. It affords an admirable synopsis of the formations between the granitic schists and the coal measures, and indeed embraces an enlarged and highly philosophical view of the science, and of its relation to the Creator.

The splendid labors of Mr. Owen, and of Dr. Mantell, on paleontology, are duly appreciated by Mr. Murchison, as are the researches of Sir Philip Egerton, Mr. Strickland, Mr. Trimmer, and others.

We have not space even to name the deserved notices which are bestowed on continental geology—the grand geological map and descriptive volumes of France, and the Paleontology of D'Orbigny; the new works of the veteran Humboldt; the labors of the Prussian, Russian, Belgian, German, Swiss, and Italian schools; the local societies and

labors of England, Scotland, and Ireland, and the wide-ranging researches that are in progress in this country.

Mr. Murchison takes honorable notice of the labors of Mr. Lyell among us, and of the co-operation of American geologists with him in carrying out his personal review of the great features of our geology. We must, however, find room, in the very winding up of our number, for adding, that Mr. Murchison has reviewed, with a faithful severity, the wide extension attempted to be made of the beautiful glacial theory of Agassiz, so splendid and satisfactory in its application to the Alps, and to all other regions where glaciers exist, or can have existed in past ages. This great subject, and with it that of drift and bowlders, the President discusses with his accustomed ability and independence, and prescribes some wholesome restraints to those whose imaginations would allure their judgment to unsustainable conclusions.

We are not willing, however, to omit the following citation, with which we shall conclude our notice:

"The other point to which I allude, and bearing at once on this view, is a discovery which our librarian has just made without quitting the apartments which he so truly adorns. In the American Journal of Science for the year 1826, vol. x, p. 217, Mr. Lonsdale has detected a short, clear, and modest statement, entitled 'Remarks on Bowlders, by Peter Dobson,' which, though little more than one page in length, contains the essence of the modified glacial theory at which we have arrived after so much debate. First describing in a few lines the manner in which large bowlders, weighing from ten cwt. to fifteen tons, were dug out in clay and gravel, when making the foundations for his own cotton factory at Vernon, and seeing that it was not uncommon to find them worn, abraded, and scratched on the lower side, '*as if done* (to use his own expression) *by their having been dragged over rocks and gravelly earth in one steady position*,' he adds this most remarkable sentence: '*I think we cannot account for these appearances, unless we call in the aid of ice as well as water, and that they have been worn by being suspended and carried in ice over rocks and earth under water.*' To show also that he had read much and thought deeply on this subject, Mr. Dobson quotes British authorities to prove, that as ice-floes constantly carry huge masses of stone, and deposit them at great distances from their original situation, so may they explain the transportation of foreign bowlders to our continents.

"Apologizing therefore for having detained you long, and for having previously too much extended a similar mode of reasoning, I take leave of the glacial theory in congratulating American science in having possessed the original author of the best glacial theory, though his name had escaped notice; and in recommending to you the terse ar-

gument of Peter Dobson, a previous acquaintance with which might have saved volumes of disputation on both sides of the Atlantic."

11. *Transactions of the Manchester Geological Society, Vol. I.*— This volume of two hundred and thirty-six pages, 8vo, is illustrated by nine beautiful plates. The subjects treated of are,

I. On some of the Objects and Uses of Geological Researches. By Dr. Black.

II. Sketch of the Geology of Manchester and its vicinity. By Mr. E. W. Binney.

III. Observations on the Lancashire and Cheshire Coal Field, with a Section. By Mr. E. W. Binney.

IV. Remarks on the Marine Shells found in the Lancashire Coal Field. By Mr. E. W. Binney.

V. On the Origin of Coal; and the Geological Conditions under which it was Produced. By Mr. J. E. Bowman.

VI. Observations on the Characters of the Fossil Trees lately discovered on the line of the Bolton Railway, near Manchester. By Mr. J. E. Bowman.

VII. On a White Fossil Powder found under a Peat Bog in Lincolnshire, composed of the siliceous fragments of microscopic parasitical Confervæ. By Mr. J. E. Bowman.

VIII. On the Fossil Fishes of the Pendleton Coal Field. By Mr. E. W. Binney.

IX. On the Economy of raising Water from Coal Mines, on the Cornish principle. By Mr. W. Fairbairn.

Note to the same.

X. Notice of Upper Silurian Rocks in the vale of Llangollen, North Wales; and of a contiguous eruption of Trap and Compact Felspar. By Mr. J. E. Bowman.

XI. Description of some New Species of Fossil Shells, found chiefly in the Vale of Todmorden, Yorkshire. By Capt. Thomas Brown.

Description of Plates.

Most of these memoirs we have attentively read, and all we have looked over with care. Rarely have we found more interesting and valuable matter within the same compass. The memoirs are accurate in observation, exact in science, sound in reasoning, elevated in moral sentiment, and dignified in style. There is in them a marked character of manliness and utility as well as of science; and Manchester, both by this volume and the productions of its earlier philosophical society, as well as by its deceased Henry, and by its Dalton, and the other living men who cultivate useful knowledge, has redeemed itself from the character of being a mere emporium of manufactures and trade.

The Geological Society has for its head the Right Hon. Lord Francis Egerton, supported by a list of officers, several of whom appear as authors in this volume of Transactions. We observe with much regret, among the dead, whom Mr. Murchison has commemorated in the annual address before the Geological Society of London, the name of John Eddowes Bowman, F.G.S., L.S., &c. Four of the eleven papers in this volume are from his pen. They are very valuable and instructive, and

derive a painful interest from being his last contributions to science. His account of the fossil trees of the coal formation, excavated within a few miles of Manchester, in digging for the rail-road to Bolton, is particularly important, and is rendered perfectly intelligible by a good section with the trees *in situ*.

12. *Fourth Report of the Agriculture of Massachusetts, counties of Franklin and Middlesex;* by HENRY COLMAN, Commissioner for the Agricultural Survey of the State. Boston: Dutton & Wentworth, State Printers. 1841. 8vo, pp. 528.—Mr. Colman is too well known to all our readers who value the advancement of the noblest human occupation, to need praise at our hands. This is the fourth, and we are sorry to say the *last* report, from his hand, of Massachusetts agriculture. We should be surprised that a state so enlightened as to institute this survey, should stop it as it were in the bud, were we not informed that the arrest was accomplished by a legislative committee, not one of whom had ever read a page of the three former reports of the able commissioner. Under these circumstances, no one can doubt but the survey which has already done so much for the State will be renewed. We are assured by gentlemen highly competent to judge, and whose practical opinion among farmers is worth every thing, that the present report is by far the most important agricultural document ever produced among us. From our own perusal, we perceive that the amount of condensed and classified information is very great, and the quotations of actual experience from the best farms in the State, give the work a standard value very different from works of purely speculative contents. It is particularly full on the dairy, and the improved breeds of cattle.

We hail with extreme pleasure the revival of agriculture in this country, looking upon it as the first, most important and happiest of merely human occupations. We ventured to predict in a notice of Liebig's Agricultural Chemistry, Vol. XL, p. 177, that the publication of that work would form a new era in agriculture. We may appeal to the history of the two past years for the truth of that statement. The press has literally teemed, during that period, with books on various departments of agriculture, but especially on agricultural chemistry. There are now not less than six or eight of these new publications on our table, hardly yet dry from the press, and almost every journal announces some new one, or new editions of those already out. The ablest men, in all parts of the world, no longer consider the subject unworthy their attention. Every thing indicates that the public mind has become thoroughly alive to the importance of its greatest physical interest, and we may confidently anticipate the best results for science and mankind.

13. *Letters and Notes on the Manners, Customs and Condition of the North American Indians, written during eight years' travel among the wildest tribes of Indians in North America in* 1832, '33, '34, '35, '36, '37, '38, '39; by GEORGE CATLIN. In two volumes, pp. 534, with four hundred illustrations carefully engraved from his original paintings.

This is a very extraordinary work—one which no reader who has once begun to peruse, will willingly lay down until it is finished.

It presents a high example of a peculiar kind of enthusiasm, in a man who possessed fine qualifications for his wild, romantic undertaking; which, however, appears chastened into right-minded sobriety, when we duly estimate the benevolence which beams in every page.

Mr. Catlin is now too well known on both sides of the Atlantic Ocean to justify an introduction by us to the public. Thousands on thousands saw his pictures of Indian features, persons and costume, with his living delineations of the noble scenery of their wide-spreading country; which with their utensils, arms, clothing, lodges, and even preserved scalps of those whom they slew as enemies, form a most unique and interesting museum; and thousands listened also in New York, to Mr. Catlin's spirited and graphic conversation and lectures, before his embarkation for Europe.

This museum, now removed to London, is probably lost forever to this country, and with it the magnificent Chinese museum of Mr. Nathan Dunn,—two collections so peculiar that they can never be replaced, and of which the final departure for the world's great metropolis, redounds little to the honor of our country.

Mr. Catlin has raised a monument to the memory of the American Indians, which will tell to posterity the incredible story that native nations of noble character have been destroyed by the invasion of war, by pestilence, fraud and alcohol, all proceeding from those who call themselves Christians, and a few among whom have vindicated their claim to this character by acts of truly Christian benevolence.

Our space will not allow us to enlarge upon this very interesting work, and we are so much gratified as well as pained by its perusal, that we feel no disposition to criticise little faults of style, or perhaps even to wish for more condensation, where the free and flowing subjects seem to justify, if not to require the same spirit in the author, traveller, adventurer, artist, philanthropist—all combined, in a manner so attractive, that we would not hazard any material alteration.

In the wilds of nature, among snowy mountains and boundless prairies and endless rivers, innumerable herds of wild horses, antelopes and buffaloes—and among tribes of Indians, as free and reckless as they, we catch the spirit of the adventurer and hurry along with him with dizzy velocity. These topics however, we must leave to the pen of literature, while we have to regret that we have no room at present to extract and condense

many facts of deep interest to some of the sciences to which our work is devoted. Mr. Catlin, before he went abroad, gave us a valuable paper on the Indian pipe quarry, (Vol. xxxviii, p. 138,) and we were much interested, during our interviews with him in New York, by the bold geological features, so vividly sketched on canvass by his pencil. We are now permitted to advert to only a single fact. Upon the upper waters of the Missouri there are vast regions bordering on the river, where the rain and snow floods have cut out of the high tertiary banks, the most extraordinary groups of cone-shaped and turreted hills, which are merely sections made by water, of a most extensive and beautiful tertiary or recent secondary formation.

The beds of clay, sand, gravel, loam, lignite and gypsum, which we well remember to have seen portrayed in lively and contrasted colors in Mr. Catlin's oil paintings, are arranged with the most exact regularity, and remain so perfectly horizontal, that no convulsion can have ever disturbed them, since they dropped from the waters which, in gone by ages, laid them down where we find them now, in brilliant sheets of strata. The lignite had been taken for coal, and it is not at all surprising, since it resembles coal so strongly in color and form. A vast country of many thousands of square miles lies in prairie, or covered by pumice, and upon the unmutilated surface presents little variety of structure; but, where it has been worn by the torrents that rush into the great river, the water has cut down these beautiful strata so as to form innumerable gorges and ravines, from the summit grass to the river's level, in altitudes varying between two and six hundred feet. The forms are, in general, elegantly symmetrical cones, either grass-clad from base to summit, or with the naked strata striped and colored in beautiful and definite contrast. The cones stand side by side and base to base, with only winding passages among them. In various instances, they are cut into pillars or columns, crowned by capitals, which are the remains of the upper strata of firmer consistence—giving to these vast mounds a castellated aspect; or, the tough tenacious clays are carved into sharp pointed minarets, like the aiguilles of the Alps, and they are grouped in such profusion, and often at the foot of the castellated pyramids and cones, that the entire assemblage rivets the eye as upon magnificent ruins of art, which, however, they entirely surpass in colossal dimensions, and exuberance of natural ornament.

From Mr. Nicollet, the accomplished scientific traveller of the west, we may expect some notices of the fossil contents of these extraordinary strata, which, from what little we have already seen, must be rich in fossils of the tertiary and the chalk.* Mr. Catlin favored us with

* Dr. S. G. Morton of Philadelphia, has already published a notice of the cretaceous fossils collected by Mr. Nicollet. (Vide this No. p. 149.)

a fine fossil turtle and the jaw of a Saurian, and the Association of American geologists saw with admiration at Philadelphia in April, 1841, the beautiful chalk fossils of Mr. Nicollet, many of them superbly adorned with their pearly coats—their nacre being almost untarnished, after the lapse of ages.

14. *New Works in Science.*—We find on our table a number of works of much interest, and all demanding more or less attention at our hands. At present we must confine ourselves with giving the titles only of some of the most important:

Memoir of the Geological Survey of the State of Delaware, including the Application of the Geological Observations to Agriculture. By James C. Booth, A. M. Dover, Delaware, 1841. 8vo. pp. 188.

Report of the British Association for the Advancement of Science for 1841, (or Vol. 10,) 8vo. pp. 480. London, 1841. J. & E. Taylor.

Bailey's Review of Berkley's Theory of Vision. London, 1842. 8vo. pp. 139.

Scientific Memoirs, Vol. III, Part 10. April, 1842.

Zoological Contributions, by S. S. Haldeman. No. 1, Feb. 1842, on some American species of Hydrachnidæ.

Coup d'Oeil sur l'Etat Actuel de nos connaissances sur Electricité, par M. A. de la Rive. From the Bibliotheque Universelle de Geneve.

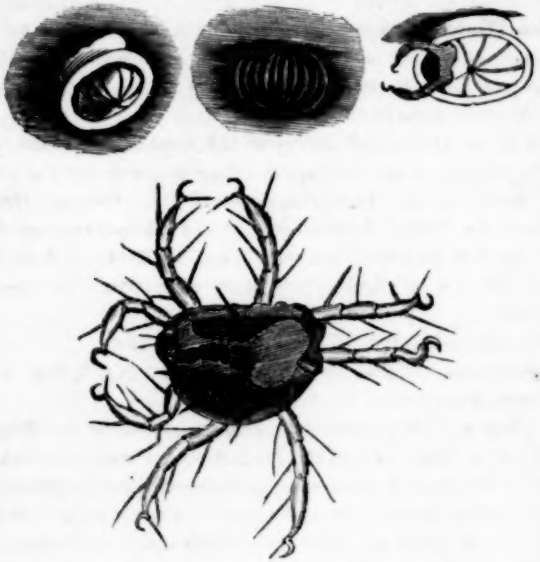
Papers on Practical Engineering, published by the Engineer Department. Bitumine, its varieties and uses. Compiled from various sources by Lt. H. W. Halleck, under direction of Col. J. G. Totten. Washington, 1841. 8vo. pp. 206, with 3 plates.

MISCELLANIES.

FOREIGN AND DOMESTIC.

1. *Microscopic Fungus.*—The fungus described by Prof. Bailey (in this Journal, Vol. XLII, p. 195, Jan. 1842) as having been received from England from Dr. Mantell, and discovered also by Prof. Bailey in the neighborhood of West Point, has since been shown to be an ACARUS, the *red fluid* arising from the puncture of the enclosed animal when in an embryotic state. In the spring of this year, the discoverer, Mr. White, found to his great astonishment that each of the supposed fungi, contained an *Acarus* of a red color, having six legs. At a late meeting of the Microscopical Society of London, Mr. White produced specimens of the animal in various states of development. The figures will show four different stages of disclosure of this so-called fungus, as it appeared to Dr. Mantell. The creature is more symmetrical than Miss

Mantell has drawn it, when seen in a more favorable point of view, but it was necessary to fix the animal in a globule of gum to keep it within view, and that has rather distorted the body; still the representation is very correct, and sufficient for the purpose. We regret that the colors cannot be seen in the engraving, as they are quite brilliant.



Prof. Bailey states that this Acarus is exceedingly common in this country, and he found its eggs near Salem, Mass. in May, as well as at West Point.

2. *Soirées of the President of the Geological Society of London*, R. I. Murchison, Esq., Belgrave Square.—The splendid mansion of this distinguished geologist was thrown open to the Fellows of the Geological Society on Saturday evening, April 23—the first of six soirées given by the President. All the savans of London were present and many distinguished foreigners. On the tables was a highly interesting series of minerals and fossils from Russia, collected by Mr. Murchison during his recent tour from St. Petersburg to the Ural Mountains. The number and variety of specimens were very great.

3. *Testimonial to Dr. Mantell.*—The clergy and principal inhabitants of Clapham Common and its vicinity, have testified their sense of the advantages derived from Dr. Mantell's lectures on physiology and other branches of science, by very appropriately presenting to that gentleman, who is one of the most persevering and successful cultiva-

tors of science in this country, through the rector, a "microscope and apparatus, value one hundred guineas; with the following inscription: 'Presented to Gideon Algernon Mantell, Esq., LL. D., F. R. S., &c. by his friends in Clapham and its vicinity, in testimony of their grateful sense of his kind and effective exertions among them for the advancement of scientific knowledge, Feb. 3, 1842.'"—*From the Lancet, (medical journal, London.)*

4. *Steam Navigation in the Pacific.*—In Vol. XLI, p. 358, we gave some account of the success of Mr. William Wheelwright in the efforts made by him to establish navigation by steam along the coasts of Peru and Chili.

Letters from him to the senior editor, dated at Guayaquil, October, 1841, and on board the steamer Chili, December 5, 1841, furnish the following additional particulars. In the letter of October, he says:—

"I now take the liberty of sending you a sample of coal from the isthmus of Panama, which you will find bearing a remarkable resemblance to that of Talca—a parcel of which I forwarded to you. We have not been able to discover any coal in the mining districts or rather the mineral districts of Peru or Chili, but the mines in Talca are every day improving in quality, and the quantity is unlimited: in fact, the whole southern country is nothing but a mine of coal. I have sunk a shaft about fifty five feet through a bed of sandstone, and there are already evident geological signs of the vein existing below. The rains have deterred me from continuing the work during the winter, but I intend resuming it in the spring.

"The progress of our steamers here has been in a measure interrupted by an unfortunate accident which occurred to the Chili—she having struck on a ledge of rocks—which has delayed her six months, but I hope in a few weeks to see her again at work.

"The prosperity of the enterprise is no longer doubtful. The coal of Talca will not exceed $2 50 per ton, put on board. The number of passengers has been doubled already, and one year more will fill the steamers constantly. I am waiting the arrival of one more steamer to complete the line to Panama."

The second letter we insert entire, as all the information it contains is interesting.

Steamer Chili, December 5, 1841.

My dear Sir—I am exceedingly indebted for your letter,* dated July 20, 1841, and for the information it contains on the subject of coal, which is most satisfactory. Since my last, we have mined about

* See this Journal, Vol. XLI, p. 362.

three thousand tons; the veins continue about the same, but the quality of the coal is much improved. We now find that the consumption is but little greater than the common English coal, and it is so favorable to our boilers and fire bars, that on the whole I consider it preferable for our purposes to any coal from England.

I am now expecting some miners from England, and intend opening some new mines as soon as they arrive, so that in case of accident my resources will not fail me. With the exception of a sad accident which occurred to this steamer, which I have since had repaired, our steam operations have gone on very prosperously. I have now the line extended to Guayaquil, and a sailing packet fills up the space to Panama until another steamer arrives from England, of which I am in anxious expectation, when the whole line will be completed, and a steam communication established between Great Britain, Chili and Peru.

It would be difficult to form an estimate of the value of steam on this coast. On my recent return from Guayaquil to Lima, in this steamer, which occupied five days, I had an opportunity of observing it. One vessel sailed four weeks before us, and was thirty six days. Another Baltimore clipper also sailed from Guayaquil a few days before us, and was twenty five days, which I consider the average passage of sailing ships from Guayaquil to Lima. From Arica to Cobya we employ two days. A ship which sailed from the former port we passed on the passage;—she finally arrived in twenty two days. These are every day and most common occurrences, and such extremes of sailing ships *versus* steam ships, can be found on the Pacific.

For some years past, the subject of opening a road across the Isthmus has been constantly before the public, but not a single step has been taken as yet to effect it. I have written to the government of New Grenada, offering to take the contract,—which, if I succeed in obtaining, I hope to render effective. I have the honor to remain, respectfully, your most obedient servant, WM. WHEELWRIGHT.

5. *U. S. Exploring Expedition.*—The U. S. corvette Vincennes, flag ship of the exploring expedition, arrived at New York, June 13, from a cruise of nearly four years—officers and crew all well.

The U. S. brigs Porpoise and Oregon, (bought to take the place of the Peacock, lost at the mouth of the Oregon, July, 1841,) sailed from St. Helena on the 24th of April for New York, via Rio de Janeiro, and may be expected soon.

The tender Flying Fish was sold at Singapore, having been nearly used up in the service, and her officers and crew transferred to the other vessels of the squadron.

The Sea Gull, with all on board, was lost in the winter of 1838–9.

The exploring squadron sailed from the United States on the 18th of Aug., 1838, and has been absent nearly four years; during which time, the different vessels have sailed about four hundred thousand miles. The expedition has thoroughly executed every part of the duties confided to it by the government.

The ports, harbors, islands, reefs, and shoals named in the list annexed, have been visited and examined or surveyed.

The positions assigned on the charts to several vigias, reefs, shoals, and islands, have been carefully looked for, run over, and found to have no existence in or near the places assigned them.

Several of the principal groups and islands in the Pacific ocean have been visited, examined, and surveyed; a friendly intercourse, and protective commercial regulations, established with the chiefs and natives; aggressions on our citizens and commerce redressed, and a justly merited punishment meted out in some flagrant cases of unprovoked and cold-blooded murder.

The discoveries in the Antarctic ocean (Antarctic continent-observations for fixing the southern magnetic pole, &c.) *preceded* those of the French and English expeditions.

The report which has been in circulation, that Capt. Ross had run over some portion of the land discovered by this expedition, is unfounded. No land to the eastward of 160° of E. longitude was discovered, seen, or claimed, by the American expedition; as appears by Capt. Wilkes's report to the Navy Department, published in 1840, after the return of the squadron to New Zealand. If this statement originated with Capt. Ross, based upon the particular chart of the Antarctic ice, and discoveries of land, with the full explanatory letter which was furnished him by Capt. Wilkes, (previous to Capt. Ross's antarctic cruise,) he (Capt. R.) must have taken that portion of land reported to have been seen by Bellamy in 1839, which was represented on it, as being in 163° to 165° east longitude or thereabouts, and which the American expedition had never seen or heard of until its return to Sydney, N. S. W. after their discoveries in the Antarctic ocean.

Capt. Ross, according to his report, has never passed over, or gone so far west as 160° east, in latitude 67° south; consequently he could not have seen the land discovered and claimed by the American expedition, but seems to have run over the position where land is reported to have been seen by his own countryman, Bellamy.

The expedition, during its absence, has also examined and surveyed a large portion of the Oregon territory, as well as a part of Upper California, including the Columbia and Sacramento rivers, with their various tributaries. Several exploring parties from the squadron have explored, examined, and fixed those portions of the Oregon territory least

known. A map of the territory, embracing its rivers, sounds, harbors, coasts, forts, &c., has been prepared, which will furnish the government with a mass of valuable information relative to our possessions on the northwest coast, and the whole of Oregon.

Experiments were made with the pendulum on "Mouna Loa" on the island of Hawaii, one of the Sandwich Islands, at a height of 14,000 feet above the level of the sea. Topographical surveys and views were made of some of its active and most extensive craters.

Experiments have been made with the pendulum, magnetic apparatus, and various other instruments, on all occasions; the temperature of the ocean, at various depths, ascertained in the different seas traversed, and full meteorological and other observations kept during the cruise.

Charts of all the surveys have been made, with views and sketches of headlands, towns or villages, &c. with descriptions of all that appertains to the localities, productions, language, customs, and manners.

At some of the islands, this duty has been attended with much labor, exposure, and risk of life—the treacherous character of the natives rendering it absolutely necessary that the officers and men should be armed, while on duty, and at all times prepared against their murderous attacks. On several occasions boats have been absent from the different vessels of the squadron on surveying duty, (the greater portion of which has been performed in boats,) among islands, reefs, &c. for a period of ten, twenty, and thirty days at one time; on one of these occasions, two of the officers were killed at the Fiji group, while defending their boat's crew from an attack by the natives.

The scientific gentlemen have been actively engaged in their various departments, and subject to all the exposures incident to researches among dangerous and hostile savages. Mr. Hale, the philologist of the expedition, was left at the Columbia river, for the purpose of prosecuting his labors among the different tribes of the Oregon territory, and may be expected home overland early in August.

Several islands not laid down in the charts have been discovered, on one of which the natives offered worship, evidently believing that their visiters had come from the sun.

The Sooloo sea has also been examined, several islands found to have been erroneously laid down on the charts, and others not laid down at all. Protective commercial regulations established with the Sultan of Sooloo, and a correct chart made of a feasible and short route for passing through these seas towards China, against the northeast monsoon.

Although the officers and crew of the expedition have been exposed to every variety of climate, the general health of the squadron has been without a precedent. But one officer (Mr. Vanderford, master's mate, who died on the passage home) and only eight of the men, have died from disease.

The officers, scientific gentlemen, and men, have been constantly employed, as will appear by the labor performed, and the results of the cruise.

In addition to the extensive collections already received from the expedition, the Vincennes has now on board a large and valuable collection, including several boxes of live plants, bulbs, &c., collected in the Pacific, Sooloo, Philippines, Singapore, Cape of Good Hope, and St. Helena.

List of ports, reefs, islands, &c., visited, examined, or surveyed, by the U. S. Exploring Expedition, during the cruise.

Ports visited.—Madeira; Port Praya, Cape de Verde; Rio Janeiro, Brazil; Valparaiso, Chili; Callao, Peru; Sydney, New South Wales; New Zealand; Manilla, Laconia Island; Singapore; Cape of Good Hope; St. Helena.

Reefs, shoals, &c. looked for and not found.—St. Ann's shoal, Maria rock, Boni Felix shoals, Bonnetta shoals, Hartwell reef, Patty's overfalls, Warley shoal, French shoal in two positions, Triton bank, Vigia, Bowvett's Sandy isles, submarine volcano of Kraisenstene.

Islands surveyed with the harbors.—*Low Archipelago.*—Clermont de Louvaire island, Serles island, Minerva do., Hondens do., Wyhite do., Otookoo do., Kings do., Raraka do., Vincennes do., Carlshoff do., Waterland do., Wilson and Peacock do., Rurick's chain, Prince of Wales, Kraisenstene's.

Society Islands.—Matie, Otahite and harbors, Eimeo: Bellinghausen, Rosa.

Navigator Group.—Manucah, Lutuella, Upolu, Monoko, Apposimo, Savaii, Wallis's island, Horn, Lord North's, Macquarie's, Eooa, Tongataboo, Harpai, Turtle.

Fiji Group—fifteen islands and fifty reefs, viz., Tulanga island, Angea, Nambus Angea bank, Angasa island, Namulka, Morambo, Engrasso, Cambia, Komo, Mothe, Karoni, Oloma, Oneata, Avia, Lakemba, Bacon's—2, Reed's—3, Nean, Tubutted, Yeaki, Hatafouga, Vanderford, Verna Ballan, Susui, Manea, Sicombia, Avla, Olohu, Muago, Hanathea, Molucio, Ohembon, Nartomba, Zelangula, Chielia, Vataia, Namko, Oneholafrango, Onuminsio, Houlelavon, Oretena, Lavatala, Kenobid, Iac, Lomo Somo, Budd, North, Maury, Holmes, De Haven, Oranibi, Okid, Lortoai, Maola, Nanai, Angasa, Gora, Batika, Vanul Levu, Morna orna, Malee, Vakai, Maeona—2 islands, Direction—4 islands, Horse Shoe Reef, Ovalow island, Moro, Neniau, Passage, Ono, Kantavu.

Passed Midshipman's Group of Islands, ten in number.—G. Endua, Bteumna, Mallana, Benga, Nuanoka, Viti Levu, Flying Fish reef.

Midshipman's Group of Islands, four in number.—Maton island, Maloio.

Waldron island, Speiden, Palmer, Perry, Alden, Case, Johnson, Carr, Walker's, Emmons.

Knox island, Davis island, Baldwin's island, Totten's island.

Vouno island, Vier Valane, Waid Lalai, Ward, Biva, Agate, Sinclair, Fox island, Eld, Naviti, Nagetta, Matatha Valie, Otoasan island, Nanoga island, Nadora, Orana, Ya Asalana, Ya Asana, Ya Roin, Mimbora, Nalon, Vendola, Tavia, Muthauata, Kinsuna, Round island, Angrajas, Gera, Chicobia, Nugulou, Corabia, Maselou, Annan, Beoia, two islands, Endura islands, and 51 reefs in this Fiji group, Gardner's island, McKean's, Hull's, Sydney, Taber, Washington or New York island, Jarvis's, Enderby's, Bennie, Duke of York, Duke of Clarence, Bowditch, Swain's, Ellen's islands or group, Tracy's island seen, Depeyster's island discovered.

Kingsmill Group.—Drummond's island, Bishop or Sydenham's, Woodle's, Henderville's, Hull's, Simpson's, Knox, Charlotte, Matthews, Pitt's islands, two, Mulgrave, Arrowsmith's, Daniels, Peddars, Pescadores, Karsakoff, two islands.

Sandwich Islands.—Oahu, Kaui, Hawaii, Maui.

Columbia River—surveyed to the cascades and falls, one hundred and twenty miles.—Straits of Quan de Fuca, Puget Sound, Nasquolly, New Dungeness, Classet Harbor; and all the harbors in that vicinity.

Examined territory of Oregon, &c.

San Francisco Sacramento.

Ladrones.—Wakes, Gusan, Assumption.

Madeira island.

Looloo islands and sea, Mangsee, Straits of Balaback, Balanquay, Rhio, Banca, Sunda, Casper, Bourbon's island, Hunter's, Barney, Favorles, Luis, McKennie's, Straits of Barandena, Vasquez island, Pylstaarts, Sunday.

Rio Negro, Cape Horn, Orange Harbor, &c.

Antarctic Continent.—*N. Y. Journal of Commerce.*

6. *Observations for Shooting Stars, April* 20–21, 1842.—During the nights of the 17th, 18th and 19th of April, 1842, the sky at this place was overcast, and observation for meteors was of course useless.

The night of 20–21st was after 11 P. M. quite clear, and observations for shooting stars were made from the summit of the Hospital, by Messrs. F. Bradley, A. B. Capwell, E. Y. Gould, G. Wood, and myself. One quarter of the heavens was assigned to a single observer. The fifth person took charge of the chronometer, and occasionally aided one of the others, generally the observer looking eastward, so that the whole number of meteors seen, may have been one tenth greater than would have been discerned by four persons only.

The watch commenced at 10*h*. 20*m*. P. M., April 20th, and continued till 4 A. M. of the 21st. During that period, shooting stars were observed, as reported in the following table:

			N.	E.	S.	W.		
10*h*. 20*m*.	to 11	P. M.	3	1	2	1	=	7
11	to 12	"	4	3	3	3	=	13
12	to 1	A. M.	5	6	4	5	=	20
1	to 2	"	10	5	5	2	=	22
2	to 3	"	8	8	5	13	=	34
3	to 4	"	15	15	12	13	=	55
			45	38	31	37		151

The moon, ten days old, interfered until 3 A. M. of the 21st, concealing probably half of the meteors which would, in case of her absence, have been visible. Morning dawned at 3*h*. 30*m*. A. M., and by 4*h*. daylight had become strong.

Arranged according to apparent magnitudes of the fixed stars, there were *greater than* 1st, 3; *equal to* 1st, 24; *equal to* 2d, 27; *equal to* 3d, and *less*, 97. Of the whole number, not one appeared to explode: about ten left trains; in the absence of the moon more trains would probably have been seen. Nothing remarkable was noticed regarding the times of flight, or the colors of the meteors.

The apparent paths were not as uniform in direction as are those of the meteors of August 10th. Nearly three fourths of them might be traced back to a region about *Corona Borealis*, but there seemed to be no very definite point of radiation. Of the remaining fourth, a few seemed to diverge from about *Spica Virginis;* and the rest moved in various directions.

The places of two of the largest meteors were noted as follows:

0*h*. 35*m*. 7*s*. A. M. 21st. A meteor equal to Jupiter, commencing in R. A. 250°, S. dec. 13°, and disappearing in R. A. 225°, S. dec. 23°. Time of flight, 0.33*s*.

1*h*. 48*m*. 28*s*. A. M. 21st. A meteor nearly equal to Mars, commencing about R. A. 35°, N. dec. 67°, and disappearing when brightest in R. A. 145°, N. dec. 60°. Time of flight, 3.0*s*.

A slight *aurora borealis* was visible during the night. At 10*h*. 20*m*. a wide faint streamer, at N. 25° W., reaching to an altitude of 12°. About this time there was an auroral bank, obscured by the haze, about 2° high, and sending forth several faint streamers. At 10*h*. 26*m*. scarce any auroral light. At 10*h*. 33*m*. several indistinct luminous spots, and obscure short streamers. At 11*h*. a faint auroral bank, 2° high, but no streamers. Scarcely any further traces of the aurora could be detected until 3 A. M. (21st,) when were seen sundry slight auroral spots, 10° or 15° E. of North and 1° or 2° high.

Observations at *Hudson, Ohio*, were made under direction of Prof. Loomis, at my request. The following results were published by him in the Ohio Observer, of May 5, 1842. "On the morning of the 19th I rose to observe, and it was perfectly cloudy. For the morning of the 20th, a watch of eight students was organized, but this time also the sky was overcast. For the morning of the 21st no regular watch was kept, but a company of students, who were riding all night in an open waggon, made such observations as they were able. About one o'clock, A. M. they began to observe, and continued about an hour, when so few were seen, that they did not pay their whole attention to it. After the moon set, which was at 3 A. M., they renewed their watch, though not uninterruptedly. From this time to morning most of the meteors were seen. They observed only the eastern half of the heavens, and saw in all about *twenty* meteors. The sky was remarkably clear all night. If the entire heavens had been observed, the number of meteors seen would probably have been somewhat less than twenty per hour. This number certainly cannot be considered very extraordinary."

From the foregoing observations, it may be concluded that there was no unusual exhibition of shooting stars at this place, or at Hudson, O., on the morning of April 21, 1842. It will be remarked, that the morning of the *twentieth* was the anniversary of the meteoric shower of April, 1803; but whether any uncommon display of shooting stars was visible on that morning, we had no opportunity to determine.

New Haven, Conn., May 17, 1842. E. C. Herrick.

7. *Botanical Necrology, &c.*—Besides the irreparable loss sustained in the death of the great De Candolle, we have to mourn the decease of several distinguished botanists during the past year, viz.

Mr. Lambert, senior Vice President of the Linnæan Society; author of a magnificent work on the Pines, and proprietor of a very large herbarium, comprising the plants of Ruiz and Pavon, of Pallas, and also of Pursh, who published his Flora under Mr. Lambert's liberal patronage.

Prof. David Don, late Curator of the Lambertian herbarium, Librarian of the Linnæan Society, and since the year 1836, Professor of Botany in King's College. This celebrated botanist, and estimable man, died on the 8th of December last, at the age of 41 years. Mr. Don's place as the botanical editor of the Magazine and Annals of Natural History, has been taken by Prof. Balfour, the successor of Sir Wm. Hooker, in the botanical chair at Glasgow.

M. Guillemin, one of the botanical editors of the Annales des Sciences Naturelles, *Aide-Naturaliste* in the National Museum at the

Jardin des Plantes, and curator of the herbarium of Baron Delessert. He died at Montpelier during the past winter, of aneurism of the aorta. The vacancy in the editorship of the Annales, is filled by M. Decaisne. The vacancy in the zoological editorship, as well as the chair of entomology in the National Museum, left by the decease of M. Audouin, is filled by Milne Edwards.

M. Carreno, the favorite pupil of the late Lagasca, and a botanist of great promise, recently died at Paris, at the early age of 23.

M. Vaucher, of Geneva, author of the *Histoire des Conferves d'eau douce, &c.*, published at the commencement of the present century, recently died at Geneva, just as his large work on the Phanerogamic plants of Europe, appeared from the press.

Dr. Vogel, of the University of Bonn, a botanist of the highest promise, is one of the victims of the ill-starred Niger expedition. Information had been received of his safe arrival among the survivors at Fernando Po; but the next account brought intelligence of his decease, which took place on the 17th of December last.

Amos Eaton, senior Professor in the Rensselaer Institute, died at Troy, N. Y., May 10th, in the 66th year of his age. The name of Prof. E. has long been associated with the unwearied and ardent cultivation of natural science. In developing the botany of our country, and the geology of the northern States, he was an early and very successful laborer. His life was eventful. In 1791, he was an apprenticed blacksmith; in 1799, he was graduated at Williams College, with much reputation for knowledge of mathematics and philosophy; soon after, he commenced the study of law, under Alexander Hamilton, in the city of New York, and in due time was admitted to the bar; leaving the practice of the law, he became a practical surveyor, and agent for the Livingston estates on the Hudson; after a period of great trial and affliction, he prosecuted the study of botany, chemistry and mineralogy to some extent in New Haven, Ct.; in 1817, and in the spring and summer of that year, delivered his first course of public lectures, to the students of Williams College, on mineralogy and botany. The patronage then received from the faculty of the College, and the high interest of a large body of the students, determined him to give courses of lectures on the natural sciences. This he did in many places. The remuneration was slight; but he was enabled to prepare for his future works, and to diffuse extensively the knowledge of these interesting subjects. In 1818, he was invited by De Witt Clinton, to deliver his public lectures at Albany, and the next winter, he lectured on chemistry and geology, before the members of the Legislature then in session. Gen. Stephen Van Rensselaer, the generous patron of merit, employed him in 1820, to make a geological survey of the country adjacent to

the great western Canal, and the result was published in 1824, in a report of 160 pages 8vo., addressed to his patron, with a profile section of the rock formations, from the Atlantic Ocean across the States of Massachusetts and New York, to Lake Erie. Prof. E. was also engaged in other more limited geological surveys, until by the munificence of Mr. Van Rensselaer, the school was established at Troy, and Mr. Eaton was solicited to be its senior Professor and director of its literary course in the year last mentioned. The Rensselaer School enabled Prof. Eaton to prosecute his favorite plan of teaching his classes, by making them experimenters and lecturers to each other. All amusements were excluded, by leading the students to take their exercise and relaxation, in the practical applications of botany, geology, and the use of instruments for mensuration, surveying, levelling, &c. Some hundreds from various States, have thus been educated under him.

While lecturing at Williams College, Prof. Eaton prepared and published, the *Genera of Plants of the Northern States*, the embryo of that "Manual of Botany," which first gave to students the botany of the various species of our plants, and which improved by repeated additions, became in the eighth edition, the "North American Botany." This work has widely spread the principles and applications of botany, being written in a popular manner, and containing full views of the science, as exhibited in the method of Linnæus.

His "Index to the Geology of the Northern States," was published in 1818, and the second edition in 1820. In 1824, he published his "Philosophical Instructor," based on *Webster's Elements of Natural Philosophy*. It is unnecessary to mention his other works upon natural history, or to refer to the various papers from his pen in this Journal. He was for years an active professor of chemistry, &c. in the Vermont Academy of Medicine, at Castleton. In geology, he published many facts of the highest consequence, and Mr. Lyell has just assented to the correctness of the doctrine advanced first by Prof. E., that our coal and anthracite belong to one geological formation. Although great modifications are making in our geology, the names given by Prof. E. to many rocks of New York, have been retained as very useful for reference. He died in peace. Benevolent and kind in his disposition, he warmly attached to himself his pupils and friends; and he will long be remembered, as an active and successful pioneer in the investigation of the natural history of his country. D.

New Publications.—In the moment of closing this number, we have received the second Bulletin of the National Institute at Washington, pp. 220, with plates—also, a volume of 582 pages, with nearly 300 wood cuts, by THOMAS EWBANK, being a history of hydraulic and other machines, and of the Steam Engine.

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ERRATA.

P. 73, l. 6 fr. bot. for *hypochlorate* read *hypochlorite;* l. 4 fr. bot. for *phosphorus* read *phosphorous.*—P. 75, l. 15, insert comma after *fluoride,* and substitute comma for semicolon after *nitrate.*—P. 93, l. 10, for *presenting* read *prosecuting.*—P. 102, l. 24, for *bank* read *branch.*—P. 292, line 13, after *snatched out* insert *of.*—P. 295, l. 14, for *front* read *forest;* l. 18, for *as* read *and.*—P. 296, l. 5, for *p.* 12 read 308. —P. 298, l. 21, for *rain* 8 2-3 *in.* read .83 *inch.*—P. 333, l. 4 fr. bot. for *turning* read *twining.*—P. 334, l. 10, for *is* read *inhabits.*—P. 336, l. 5, dele *campanulate.*

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